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In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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CONTENTS

CONTENTS—continued

RADIOLOGICAL HEALTH DATA AND REPORTS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

PROGRESS ON METHODS FOR REDUCING STRONTIUM-90 IN WHEAT AND MILLED PRODUCTS

R. A. Anderson and *V. F. Pfeifer* [1]

SYNOPSIS—Various simple cleaning techniques were applied to four varieties of Kansas hard red winter wheat, to determine their effectiveness in removing strontium-90. As much as 73 percent of the strontium-90 content in wheat and 80 to 83 percent in bran was removed by washing with dilute phosphoric or citric acid. This treatment also produced substantial reductions in the strontium-90 content of flour.

The levels of strontium-90 in wheats grown in various parts of the United States are decreasing. In 1963, the average strontium-90 level in U.S. wheats was about 220 pCi/kg (*1*), and this level fell to approximately 135 pCi/kg in 1964 (*2*). Unless above-ground nuclear testing is resumed, this level is expected to decrease. In event of an emergency, however, in which there would be heavy contamination of wheat by radioactive fallout, information must be available to permit the decontamination of wheat, or milled products from it, to levels suitable for consumption in foods and feeds. This laboratory is investigating this problem and is developing methods to reduce the strontium-90 content in wheat and its milled products.

In wheat, the absorption of radioactive material depends upon the state of development of the plant at the time of fallout and upon the amount of rainfall during development of the heads. If rainfall is slight during and after head growth, the wheat will contain much less radioactivity than if the rainfall occurs during head formation. At present 80 to 90 percent of the strontium-90 in wheat results from foliar deposition of fallout and about 10 to 20 percent from root absorption from the soil (*3-5*). It was also found that the outer layers of the berry, the beeswing, and the bran layers were most heavily contaminated and that the endosperm was contaminated to a lesser degree (*6*).

The studies have been directed toward reducing radionuclide contamination in wheat by the application of simple cleaning techniques to the whole grain before milling.

Materials

These investigations were conducted on a wheat blend made up of four Kansas hard red winter wheats from the 1963 crop, selected on the basis of their strontium-90 level. The blend contained Bison, Pawnee, Tascosa, and Triumph varieties and had a strontium-90 content of 395 pCi/kg of wheat (as-is basis). This blend was milled on a Buhler [2] experimental mill into patent flour, clear flour, shorts, and bran that were analyzed for strontium-90.

Methods

Strontium-90 was determined by a modification of the method of Harley (*7*); however, procedures followed in the treatment and subsequent handling of the treated grain will be detailed. In all experiments, milling was carried out on the Buhler mill after the grain was tempered to 15 percent moisture overnight and to 15.5 percent 30 minutes before milling.

Dry treatment

The application of dry scouring or dehulling techniques to remove the outer layers of the wheat was carried out in three different machines; a Eureka laboratory wheat scourer, a

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[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

CeCoCo rice huller, and a Squiers rice huller. The wheat scourer consists of a rotor fitted with rubber paddles surrounded by a screen and equipped with aspiration devices. This machine subjected the wheat to a rather mild scouring action. The CeCoCo machine has a cone-shaped abrasive roll, for removing the outer layer of the grain, surrounded by a screen. The degree of hull removal by the machine is regulated by a weighted discharge gate, and any amount of the wheat may be abraded from the kernel. In the study, 4 to 17 percent of the kernel was removed. The Squiers huller is a machine for dehulling and polishing rice and consists of two sections. In the first section, a solid-cast rotor with several bars, surrounded by a screen, causes the grains to be rubbed against the rotor, screen, and one another, thereby removing the outer layers of the kernel. The second section contains a polisher, a series of leather straps that remove the remaining loosened, but adhering hull from the berry. In using this huller, we attempted to remove about 4 percent of the grain, which consisted primarily of beeswing, the outermost portion of the wheat. This particular procedure has been described by Earle (*8*).

After the wheat was treated in these three machines, the grain was milled, and the various fractions were analyzed (table 1).

Table 1. Scouring and dehulling wheat to reduce strontium-90

Treatment machine	Strontium-90 content after treatment, pCi/kg (as-is basis)					
	Wheat	Beeswing, dust, etc.	Bran	Shorts	Clears	Patent flour
Control	395		1,570	527	49	34
Scourer:						
1 pass, 0.5% removal		2,190	1,640	562	44	35
2 passes, 2.2% removal		2,040	1,380	484	54	37
CeCoCo dehuller:						
4% removal	302	3,200	1,320	540	55	37
7% removal	262	2,390	1,152	412	54	45
12% removal	235	1,870	1,180	470	54	42
17% removal	208	1,600	1,330	542	54	36
Squiers dehuller:						
4% removal	235	4,375	960	598	74	37

Mild scouring of the wheat removed only a small quantity of outer layer material and gave almost no reduction in strontium–90 in the milled fractions. The CeCoCo machine reduced strontium–90 by less than 25 percent when 4 percent of the grain was removed. When 17 percent of the grain was removed, strontium–90 was reduced by 47 percent. As the dehulling percentage increased beyond about 4 percent, the bran layer was attacked, and at 17 percent a sizeable amount of endosperm was also abraded. This loss of endosperm, of course, is undesirable from the millers' standpoint. Also, at the 12 and 17 percent removal levels the strontium–90 content of the bran and shorts fractions started to increase, after being reduced at the 4 and 7 percent levels.

Removal of essentially the outer layer of the wheat berry was best accomplished in the Squiers dehuller. By removing about 4 percent of the berry, about 40 percent of the strontium–90 was removed from the wheat with about the same reduction in the bran fraction. The other milled fractions did not change materially with respect to strontium–90 content. The high count in the outer layer fraction obtained by this treatment demonstrates the large degree of contamination on the outside of the grain.

Wet treatment

From data obtained in the dry milling experiments, it was obvious that another approach must be taken to the problem and that the application of wet or washing treatments to the grain should be investigated. Grain was washed in water for various periods of time, centrifuged, and dried. It was then tempered and Buhler milled into the usual fractions (table 2).

Table 2. Washing wheat with water to reduce strontium-90 content, temperature 75° F.

Treatment	Strontium-90 remaining, pCi/kg (as-is basis)					
	Wash time (hours)	Wheat	Bran	Shorts	Clears	Patent flour
Control		395	1,570	527	49	34
Distilled water	3½	426	1,561	627	44	33
Tap water [a]	1/60	365	1,388	455	44	32
Tap water [a]	3½	210	826	435	49	31
Tap water [a]	10	176	588	350	42	34
Tap water [a]	24	156	542	277	39	33
Tap water [a]	48	116	393	306	42	35

[a] Peoria, Illinois, tap water with a total hardness of about 300 ppm (as $CaCO_3$).

Washing the grain in distilled water gave essentially no reduction of strontium–90 in the wheat or its milled fractions, but washing with Peoria City tap water gave progressively

greater reductions in strontium–90 in the wheat, bran, and shorts as the time of washing was increased. After 48 hours of washing, 71 percent of the strontium–90 was removed from the grain, reflected in decreases of 75 percent in the bran and 42 percent in the shorts fraction. Very little, if any, reduction of strontium–90 was obtained in the flour fractions by this treatment.

Washing wheat in certain dilute chemical solutions to reduce strontium–90 content was also studied. Additives were selected for their complexing, surface-acting, or sequestering properties, as well as their low cost and ready availability. In these experiments, grain was washed for 3½ hours in the appropriate solution with the solution replaced each hour. Two temperatures, 75°F. and 110°F., and two concentrations, 0.17 percent and 0.5 percent, were studied. After treatment, grain was centrifuged and dried. It was then tempered and milled as already described. Table 3 lists data obtained from chemical washings.

Table 3. Washing wheat with chemical additives to reduce strontium-90 content, wash time 3½ hours

Treatment	Strontium-90 content after treatment, pCi/kg (as-is basis)				
	Wheat	Bran	Shorts	Clears	Patent flour
Control (no washing)	395	1,570	527	49	34
Temp. 75°F. conc. 0.17%:					
Mixed phosphates	197	889	447	41	32
Citric acid	160	462	264	37	28
Gluconic acid	190	720	328		
Sodium gluconate	322	1,350	532		
Phosphoric acid	106	383	269		
Acetic acid	164	615	344		
Lactic acid	123	407	283		
Temp. 110°F. conc. 0.17%:					
Citric acid	117	338	174	42	28
Vel [a]	194	745	425		
Calgon [a]	139	460	251		
Phosphoric acid	113	328	212	29	30
Temp. 110°F. conc. 0.5%:					
Citric acid	105	300	137	27	26
Phosphoric acid	110	258	202	37	27

[a] Vel is a commercially available detergent, and Calgon is a mixture of food-grade sodium phosphate with soda ash and other carbonates of soda.

Significant reductions in the strontium–90 content of the wheat, bran, and shorts were accomplished by most of the treatments used. The best results were obtained with citric, lactic, and phosphoric acids. From 70 to 73 percent of the strontium–90 was removed from the wheat and up to 81 to 83 percent from the bran. There were substantial reductions in the strontium–90 content of clear and patent flours when citric and phosphoric acids were used. It appears that both temperature and concentration contribute to the decrease in strontium–90 in the wheat and milled fractions.

The combination treatment of dehulling and washing the dehulled wheat in citric or phosphoric acids did not reduce strontium–90 in the wheat and milled fractions any better than did washing alone. Indeed, washing the dehulled wheat had to be restricted to 1 hour because in a longer period the wheat became soggy and subsequent milling was affected.

Vacuum treatment

Washing the wheat in chemical solutions under relatively high vacuum was attempted in an effort to reduce the time involved. In these experiments, wheat was placed in a vacuum dryer, which was evacuated to about 28 inches Hg, and then the solution to be used was added. After the desired period of time, the vacuum was released, the solution drained, and the grain centrifuged and dried. The wheat was then tempered and milled in the usual manner. The data in table 4 indicate that it is necessary to have adequate contact time with the washing solution to obtain a significant reduction in strontium–90. Of the washes tried, the phosphoric acid gave the best results, particularly at the higher concentrations.

Table 4. Washing wheat under vacuum (28 inches Hg) to reduce strontium-90 content

Treatment	Strontium-90 content after treatment, pCi/kg (as-is basis)				
	Wheat	Bran	Shorts	Clears	Patent flour
Control	395	1,570	527	49	34
Temp. 75° F. 30 seconds:					
0.17% citric acid	269	1,050	523	41	34
Temp. 110° F. 10 minutes:					
0.17% citric acid	224	800	457	50	32
0.17% Vel	268	955	553		
0.17% phosphoric acid	211	685	298		
0.67% phosphoric acid	130	422	308		
Temp. 110° F. 30 minutes:					
0.17% phosphoric acid	136	530	294		
0.5% phosphoric acid	99	445	291		

Conclusions and future work

From the work completed to date, it is concluded that the strontium–90 content of wheat resulting from fallout can be reduced significantly by washing the grain in dilute phosphoric or citric acid. Reductions as high as 73 percent in the wheat and from 80 to 83 percent in the bran have been accomplished. Substantial reductions in strontium–90 in flour fractions have also been achieved. It must be pointed out, however, that the contaminated

wheat studied was quite low in strontium-90, although it had the highest level obtainable in farm-grown wheat. We would expect considerably greater reductions in more heavily contaminated grain.

Future studies will be directed toward development of a simple, feasible, and economical method based on reported results. The effect of the additive, temperature, and other variables on the milled products, particularly the flour, is currently being considered. Changes in baking quality of the flour because of these factors will be critical for any method to be acceptable by millers. Preliminary farinograph and baking tests indicate that essentially no damage occurs to the flour as a result of the dilute acid treatments.

Acknowledgement

We are grateful to L. H. Burbridge, John Kerr, D. E. Uhl, F. B. Alaksiewicz, and L. P. Stoltz for their assistance throughout these studies.

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CESIUM-137 IN MILK, MEAT, AND MAN IN NORWAY, 1962-1965[1]

Kjell Madshus, Aksel Stromme, and Kristian Koren[2]

SYNOPSIS—Studies in Norway indicate regular seasonal patterns of cesium-137 concentrations in milk with a general increase in mean concentration from 75 pCi/liter in 1962 to 300 pCi/liter in 1965 in spring milk. Increases in cesium-137 body burdens from 16.0 to 80.9 nanocuries, observed from March 1963 through October 1964, roughly paralleled increases in milk concentrations of cesium-137 for this period. Results of anaylses for cesium-137 in lamb and beef ranging from 0.3 to 23.7 nCi/kg of meat are given, but no trends are indicated. Lamb showed higher concentrations than beef.

During the last few years, considerable interest has been expressed in determining the cesium-137 body burdens of humans. Particular emphasis has been placed upon those persons living at latitudes near the Arctic Circle.

This paper summarizes selected results from studies of cesium-137 concentrations in milk and meat, and the resultant body burdens in humans from Norway.

Milk

The cesium-137 content of Norwegian milk has been studied with particular interest. It is of significance to note that daily per capita milk consumption in Norway has increased from 0.59 liters in 1962 to 0.63 liters in 1964. However, effective comparison of the importance of cesium-137 in milk as related to the diet must also include the amounts of other dairy products consumed, such as cheese and butter.

Milk surveillance activities have been conducted in cooperation with the Norwegian Milk Producers National Association. Since February 1963, monthly samples have been collected from 30 dairies. The location of these dairies is given in figure 1.

For comparison purposes, one can from meteorological considerations divide Norway into three zones coinciding with the concentrations of cesium-137 in spring milk. These three zones are shown in figure 1.

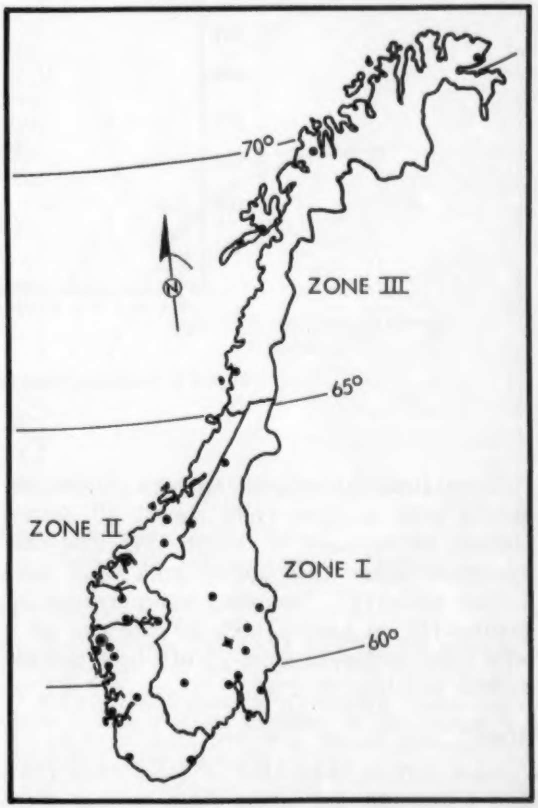

Figure 1. Norwegian zones and dairy locations

[1] This work was supported by U.S. Atomic Energy Commission Contract No. AT (30-1)-3364.

[2] Mr. Madshus is a physics engineer at Norsk Hydros Institute for Cancer Research, Dr. Stromme is a physician at the Norwegian Radium Hospital, and Mr. Koren is the director of the State Institute of Radiation Hygiene in Norway.

The concentrations of cesium-137 varied considerably from dairy to dairy in the same county and often inversely with the amount of milk distributed by the dairy. Mean concentrations were therefore determined by weighting concentrations in each county or zone by the respective amount of milk distributed.

The monthly concentrations of cesium-137 in milk were observed to exhibit seasonal variation, with the minimum concentrations occurring between January and May each year. Figure 2 shows the average monthly concentration in each zone and in Norway as a whole for March 1963 through March 1965. The concentration curves exhibit the same patterns in each zone, with a minimum in late winter and spring, a rapid increase in June with a peak in late summer, and a decrease during the fall.

Table 1. Mean concentrations of cesium-137 (pCi/liter) in spring milk in the three zones and Norway, 1962–1965

Area	Mean concentration, (pCi/liter)			
	1962	1963	1964	1965
Zone I	25	80	195	155
Zone II	115	210	310	410
Zone III	220	245	435	555
Norway	75	145	265	300

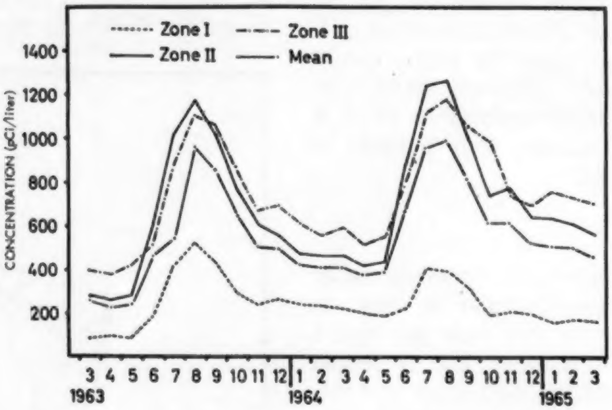

Figure 2. Seasonal variations of cesium-137 in cow's milk

From 1962 through the spring of 1965, the spring milk samples from almost all dairies showed an increase in cesium-137. The only exception is the 1965 spring milk from Zone I (see table 1). The mean concentration of cesium-137 in spring milk in Norway as a whole has increased from 75 pCi/liter in 1962 to 300 pCi/liter in 1965.

Meat

As a part of these studies, meat from cows and 5-6-month old lambs from several Norwegian slaughterhouses where animals from the local districts are slaughtered (all together 28 slaughterhouses) has been systematically collected every 2 months. The locations of these slaughterhouses are shown in figure 3. All samples are taken from the same part of the animal, *i.e.*, the semi-tendinous muscle. This is a precaution taken because there are some reports which indicate that the concentration of cesium-137 can differ from muscle to muscle in the same animal (*1*). The age of the animal is not considered in this study.

Cows are slaughtered for meat all the year round, but lambs ordinarily are killed in late fall. The samples of beef and lambs' meat came from the same slaughterhouse except in two cases. All samples in this study are from late fall 1964.

Using the three arbitrary zones shown in figure 1, the results in this study are shown in table 2. From this table, no obvious correlation can be adduced between the concentrations of cesium-137 in lamb and beef.

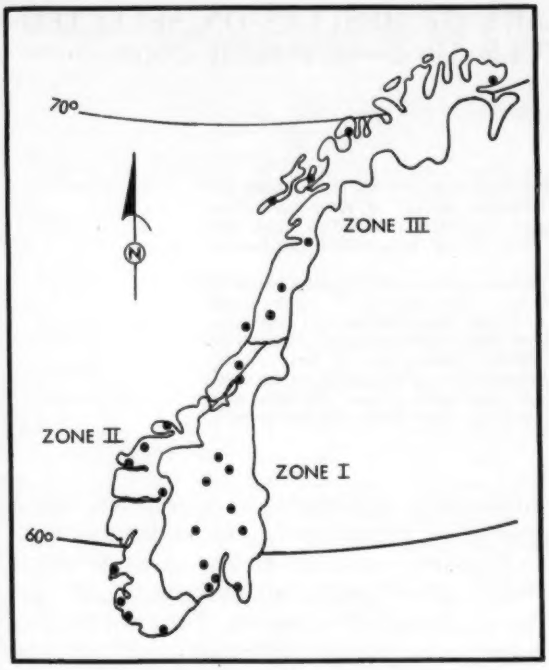

Figure 3. Slaughterhouse locations

Table 2. The mean, maximum, and minimum concentrations of cesium-137 in meat, late fall 1964 (nCi/kg fresh meat)

Area	Lamb (nCi/kg)			Beef (nCi/kg)		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Zone I	6.7	17.4	1.6	0.9	2.6	0.3
Zone II	10.0	23.7	2.4	2.5	4.4	1.6
Zone III	8.5	14.7	4.0	2.3	4.1	0.8
Norway	8.2	23.7	1.6	1.8	4.4	0.3

Humans

The cesium-137 body burdens of 23 Norwegian schoolboys (from Zone 1) have been determined by means of a whole body counter at the Norsk Hydros Institute for Cancer Research (*1*) and are shown in table 3 and along with the spring milk data in figure 4. It can be seen that the body burdens increased from March 1963 through October 1964, roughly paralleling the milk cesium-137 values. In a study reported elsewhere, a trend toward higher cesium-137 body burden has been noted among those with a large milk consumption (*2*).

Table 3. The body burdens of cesium-137 in 23 Norwegian schoolboys from Zone I

Date measured	Body burdens, nCi		
	Mean	Maximum	Minimum
March 1963	23.2	16.0	43.5
October 1963	44.9	27.9	64.5
March 1964	47.2	24.8	67.5
October 1964	49.9	30.7	80.9

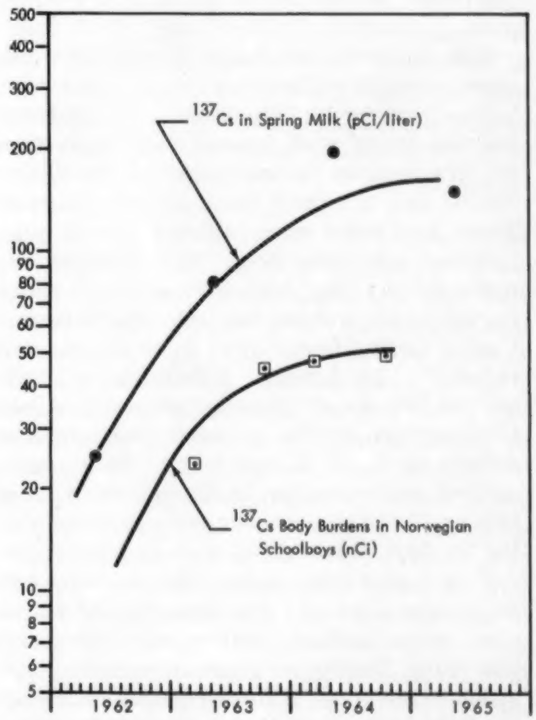

Figure 4. Norwegian cesium-137 milk concentrations and cesium-137 body burdens in schoolboys

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STRONTIUM-90 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962—OCTOBER 1963.

Lloyd R. Setter, Donald Smith, and Mozart Spector[1]

SYNOPSIS—Strontium-90 content and strontium-90/calcium ratios are summarized for nine staple foods sampled during a six-consecutive-quarter household survey which began in July 1962. The data are grouped into six broad geographical regions of production insofar as possible.

Strontium-90 concentrations in whole milk and evaporated milk showed regional differences and observable trends in a 3- or 6-month period; strontium-90 concentrations in bread had similar but less pronounced trends. Regional trends in strontium-90 were least discernible for potatoes, eggs, meat, fruit, and oleomargarine, due in part to the low strontium-90 content per unit weight and presumably to interregional shipment of food and feed. Foods such as cabbage, potatoes, and fruit had strontium-90/calcium ratios greater than those for whole milk and evaporated milk.

This study was conducted as part of a program to assess radiation exposure to the population from foods. The Division of Radiological Health collected selected food items from the principal marketing areas of the United States, and examined them for radionuclides. These food items were collected for six quarters beginning July 1962. This collection was made concurrently with a Food Consumption Survey which was conducted by the Bureau of Census for the first four of these six quarters in behalf of the Division of Radiological Health and the Division of Chronic Diseases. The Food Consumption Survey covers a representative sample of the U.S. population. This sample covered approximately 10,000 households comprising 30,000 persons who were surveyed during the first two weeks of each quarter (*1, 2*).

This report summarizes the measurements of strontium-90 and the strontium-90 to calcium ratios in food samples collected during this study. During each survey period, the Division of Radiological Health arranged, through the PHS Division of Environmental Engineering and Food Protection, to have local food experts collect samples of each of the selected food items from the marketing centers. The selection of samples was based on the varieties and amounts of foods available at the time of sampling as indicated by appropriate USDA marketing reports and local marketing data.

Primary consideration was given to staple foods such as bread, fruit, milk, meat, and vege-for all six sampling periods. The fruit samples were apples for the first four samplings, and oranges for the last two. Whole milk samples were those of the Pasteurized Milk Network of the Division of Radiological Health, collected during each of the 2-week periods of sampling. The meat was ground chuck beef for the first four samplings, and lean pork for the last two. The green vegetable samples were lettuce for four samplings, and cabbage for two samplings. Evaporated milk was sampled for five periods, eggs and potatoes for four periods, and oleomargarine and breakfast cereal for two periods. Coffee beans and instant coffee were also sampled and tested. The results on coffee, however, showed that its contribution to strontium-90 intake was negligible in relation to total intake. For this reason, results of the coffee sampling have been omitted from this report. Table 1 lists the number of samples of each item collected in the conterminous United States for each sampling period.

Food sampling and analysis

The collected food samples were packaged and sent to regional laboratories of the Division of Radiological Health for determination of the radionuclides in the edible portion. In some instances, food wastes such as apple peel and core, or beef bone, were also examined.

[1] The authors are staff members of the Technical Operations Branch, Division of Radiological Health, U.S. Public Health Service, Department of Health, Education, and Welfare, Washington, D.C. Dr. Setter is physical science advisor for the Branch; Mr. Smith is chief, Field Testing Group of the Radiation Intelligence System; and Mr. Spector is chief, Statistical Analysis Group of the Radiation Intelligence System.

Table 1. Number of food samples collected in the conterminous United States during quarterly survey periods

Food samples	July 1962	Oct 1962	Jan 1963	Apr 1963	July 1963	Oct 1963	Total
Milk:							
Whole [1]	91	87	93	117	117	110	612
Evaporated	NS	48	35	34	25	28	170
Bread:							
White	61	50	44	45	55	53	308
Fruit:							
Apples	13	47	29	25	NS	NS	114
Oranges	NS	NS	NS	NS	14	11	25
Meat:							
Beef	13	14	13	12	NS	NS	52
Pork	NS	NS	NS	NS	21	25	46
Vegetables:							
Lettuce	40	26	24	15	NS	NS	105
Cabbage	NS	NS	NS	NS	24	32	56
Eggs	NS	NS	27	27	26	25	105
Potatoes	NS	NS	18	27	31	33	109
Oleomargarine	NS	NS	29	27	NS	NS	56
Cereal	NS	NS	NS	NS	34	32	66
Total	218	269	312	329	347	349	1,824

[1] Regular Pasteurized Milk Network samples of the Division of Radiological Health collected from the regional areas listed in figure 1.
NS, no samples collected.

Although only strontium–90 results are presented in this report, the analyses included determination of gamma-emitting radionuclides, barium-lanthanum–140, potassium–40, zinc–65, ziconium-niobium–95, cesium–137, ruthenium–103+106, iodine–131, and cerium–141+144, the radiochemical measurement of strontium–90, strontium–89, total radium, and the stable elements calcium, phosphorus, and potassium. Potassium was determined either by flame photometry or from the gamma measurement of potassium–40. A report on cesium–137 determinations and $^{137}Cs/K$ ratios is in preparation.

Interlaboratory comparison of analyses

Three laboratories of the Division of Radiological Health were primarily responsible for food analyses. Analytical control studies were conducted on portions of food ash from each of the type of foods sampled in the first three samplings. Ash samples were prepared from market foods and distributed to each of the Division's five laboratories for analyses. The results indicated that agreement between laboratories was satisfactory — generally within 25 percent of the mean for individual samples.

Regional comparisons

The regional areas selected for this study are those used by Morgan (*3*), except that the geographical pattern of strontium–90 concentrations in milk warranted a further subdivision of the West and the South. The West was divided into a Northwestern region including the States of Washington, Oregon, Idaho, Montana, and Wyoming; and a Southwestern region including the States of California, Nevada, Utah, Arizona, Colorado, and New Mexico. The strontium–90 concentrations in milk samples of the Southwestern region were usually less than those in samples of the Northwestern region. The strontium–90 in milk samples from the central part of the Southern region (namely, those samples collected from the area about 100 miles on either side of the Mississippi River from Memphis, Tennessee, to the Gulf of Mexico) appeared higher than that in other samples of the Southern region. When available for a particular food category, these have been listed in a "Delta" region. The geographical boundaries of the resulting six regions are shown in figure 1.

Further subdivision of components of the diet in the United States is not warranted, because food production, distribution, and marketing frequently assume a very complex pattern. For example, eggs are produced in every State of the Nation; however, the majority of the poultry feed is raised in the North Central United States. Beef animals raised on local pasture in one region may be fattened for market in another region on rations raised in a third region. The marketing of some products may be centralized. For example, the meat of over 80 percent of the beef animals is distributed from only 17 major markets in the United States. Whole milk, on the other hand, is largely of local origin throughout most of the United States. Therefore, the identification of food from production areas in the United States may be simple or very complex, but economical marketing usually favors a minimum cost of transportation.

Average strontium–90 concentrations in food

Data on strontium–90 and ratios of strontium–90 to calcium for each of the various food items are given in the appendix (page 74). The table consists of all the data on each food item for each sampling period. Waste portions of several samples which were composited and analyzed separately are also given.

Figure 1. Regional areas for 1962–1963 food survey (modified regions used by Morgan—see reference 3)

The average strontium-90 concentration and the strontium-90/calcium ratio for each of the food items and for each quarter are shown in figure 2. Those foods sampled for at least five periods are listed in descending order of strontium-90 concentration: evaporated milk, whole milk, bread, vegetables, fruit, and meat. The remaining foods, which were sampled after the first two samplings, are eggs, potatoes, oleomargarine, and breakfast cereal, which are arranged in that order in approximately an ascending concentration of strontium-90 also shown for each sampling is the ratio of strontium-90 to calcium (pCi/g). It is interesting to note that the ratio for evaporated milk and whole milk is less than the numerical value of the concentration (pCi/liter, or pCi/kg), whereas the reverse is true for the other foods. This simply means that the calcium content per kilogram of evaporated milk or per liter of whole milk exceeds 1 gram, and for the remaining foods, the calcium is less than 1 gram per kilogram.

Because it is recognized that the human body discriminates against strontium in favor of calcium (*4, 5*), consideration should be given to the relative importance of foods in the diet, based on both strontium-90 and calcium contributions. Thus, on a unit weight of food basis, it appears that breakfast cereal, green vegetables, fruit, potatoes, and meat would be rated of greater significance than milk products. This would be especially true if the dietary calcium requirements were supplied largely from foods such as those tested, other than the milk products.

Figure 2 reveals trends which appear significant. The bars for both evaporated milk and whole milk show increases in strontium-90 between the fourth and fifth samplings (April-July 1963). This is interpreted as the break between harvest years for the feeds. The remaining foods also show some evidence of a similar break and are, in part, the basis for evaluations on a harvest year, rather than a calendar year summation. In the case of some foods, such as apples (for four sampling periods), it appears that the first sampling reflects a carryover of produce from the previous harvest year. The fifth fruit sampling (oranges) similarly appears to be a mixture of food produced in two harvests. Eggs and meat, probably because the feed may be a mixture from many sources and several years, maintain a relatively uniform strontium-90 content during the period of the study.

Breakfast cereal had the highest strontium-90/calcium ratio (figure 2). There were variations of strontium-90 content and strontium-90/calcium ratios among the various kinds of cereal. No attempt was made to relate these samples to regions of production, since the number of samples was small and little information was available on the origin of the principal grain in the brand-name products. The results of these samples were grouped according to major grain component, averaged as shown in the appendix, and plotted in fig-

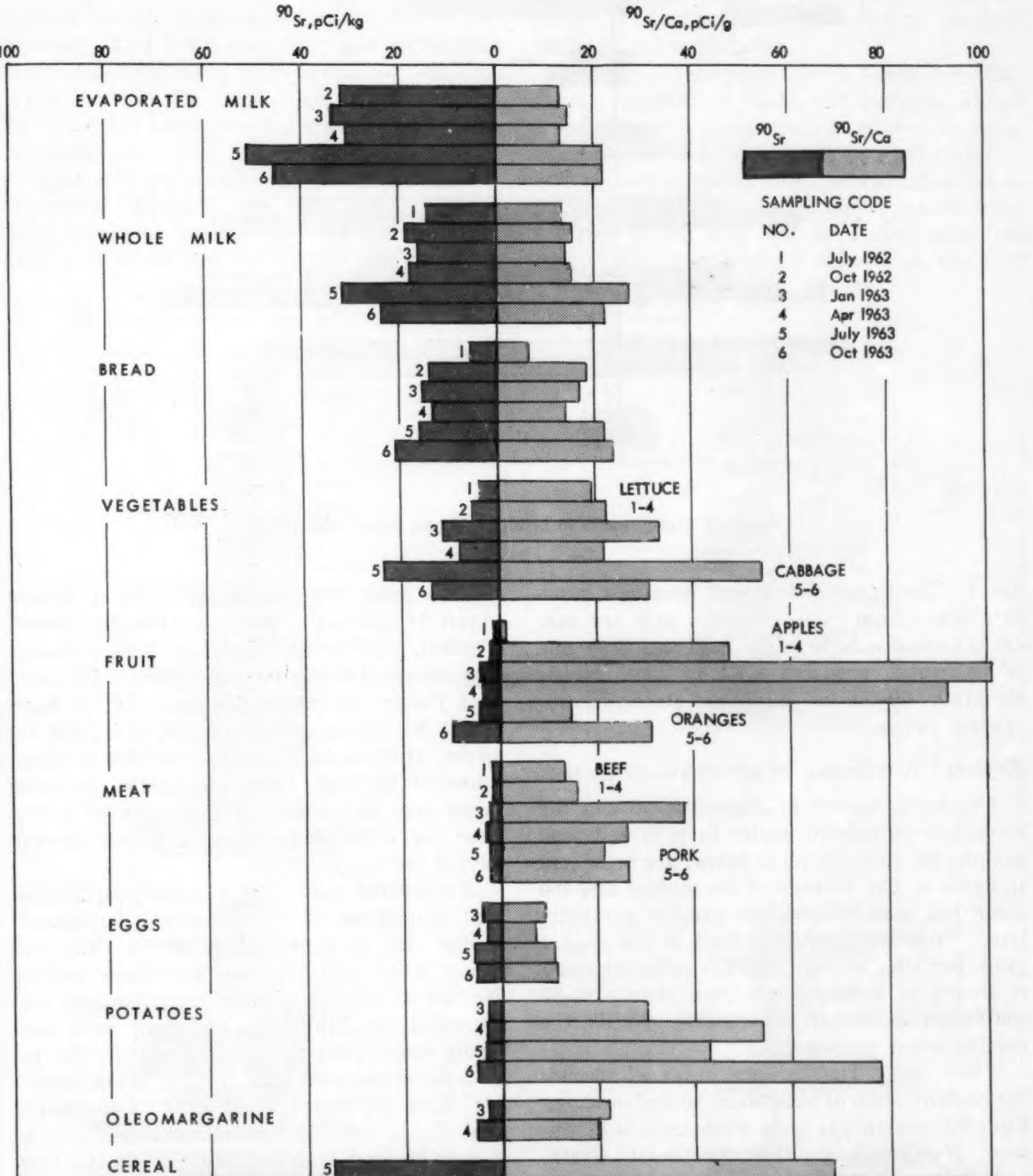

Figure 2. Strontium-90 and strontium-90/calcium ratios in foods, July 1962–October 1963

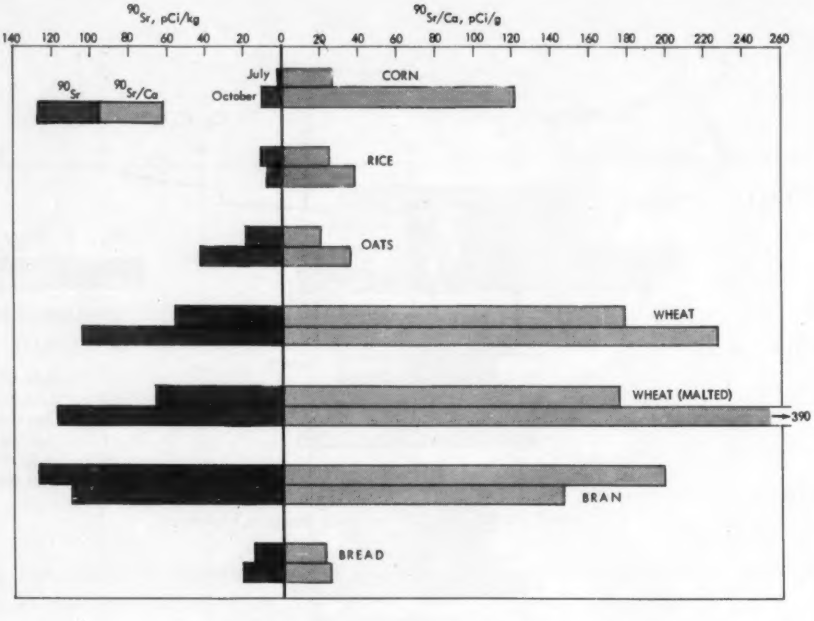

Figure 3. Strontium-90 in breakfast foods, July–October 1963

ure 3. The figure shows that breakfast products made from corn, rice, and oats are generally comparable to bread, whereas bran and whole wheat products tend to have higher strontium-90 concentration and strontium-90/calcium ratios.

Regional distribution of strontium-90 in food

The concentration of strontium-90 and the strontium-90/calcium ratios in milk and food samples for each sampling period are presented in figure 4. The average of the median and the mean has been adopted for graphic presentation. When the calcium content is less than 1 gram per kilogram of food, the ratio (shaded) is shown as a larger bar than strontium-90 concentration (solid). In the case of milk, the reverse order is evident.

Whole milk: The regional order of ascending concentration of strontium-90 and of strontium-90/calcium ratios in whole milk is Southwest, Northwest, Central, Northeast, South, and Delta. Over the six periods, the strontium-90/calcium ratio (average of mean and median) was 7.3 pCi/g for the Southwest and 26.3 for the Delta region, or a 3.6-fold spread. Moreover, a sharp rise in strontium-90 is apparent after the fourth sampling (between April 15 and July 1963) for the Northwest, Central, and Northeast regions. Also, a smaller but comparable rise appears between the third and fourth samplings (January 15 to April 1963) for the Southwest, South, and Delta regions. It is assumed that the increase in strontium-90 between these two dates indicates what may be termed the beginning of a new year for milk production and a new growth period for many crops.

Evaporated milk: The regional distribution and magnitude of the strontium-90/calcium ratios are, in general, similar to those for whole milk. The first four samplings for the Northwest showed similar concentrations and ratios to the Southwest, and both were generally lower than the Central region; the ratios for evaporated milk for the South resemble those for Delta whole milk. Considering that the inventory of evaporated milk is 1 to 3 months, and high exporting from the Central region was suspected, it is not unreasonable that the evaporated milk for the South and Delta regions would reflect the values for whole milk from Central, as well as local, production.

Bread and meat: These two commodities show little regional variations. A seasonal trend in a new harvest year for bread is indicated for the Southwest and the South, beginning April 1963, and for the Central and Northeast, beginning July 1963. No seasonal trend is shown for meat—due, in part, to the fact that the meat sampled was beef for four samplings, and lean pork for the last two.

Eggs and potatoes: The concentration of strontium-90 was low and comparable in these two foods, but potatoes are very low in calcium and hence had the highest strontium-90 calcium ratios of the food tested. There was, however, no substantial evidence of a regional variation and, over the four sampling periods embracing two production seasons, no seasonal variation of importance.

Fruit and vegetables: Since there were different varieties of these, the regional differences, if any, are obscured. A gradual increase in the strontium-90 content in apples and in lettuce was observed for the first four samplings. The Southwest oranges, which were sampled in the fifth and sixth samplings, had considerably less strontium-90 than those of

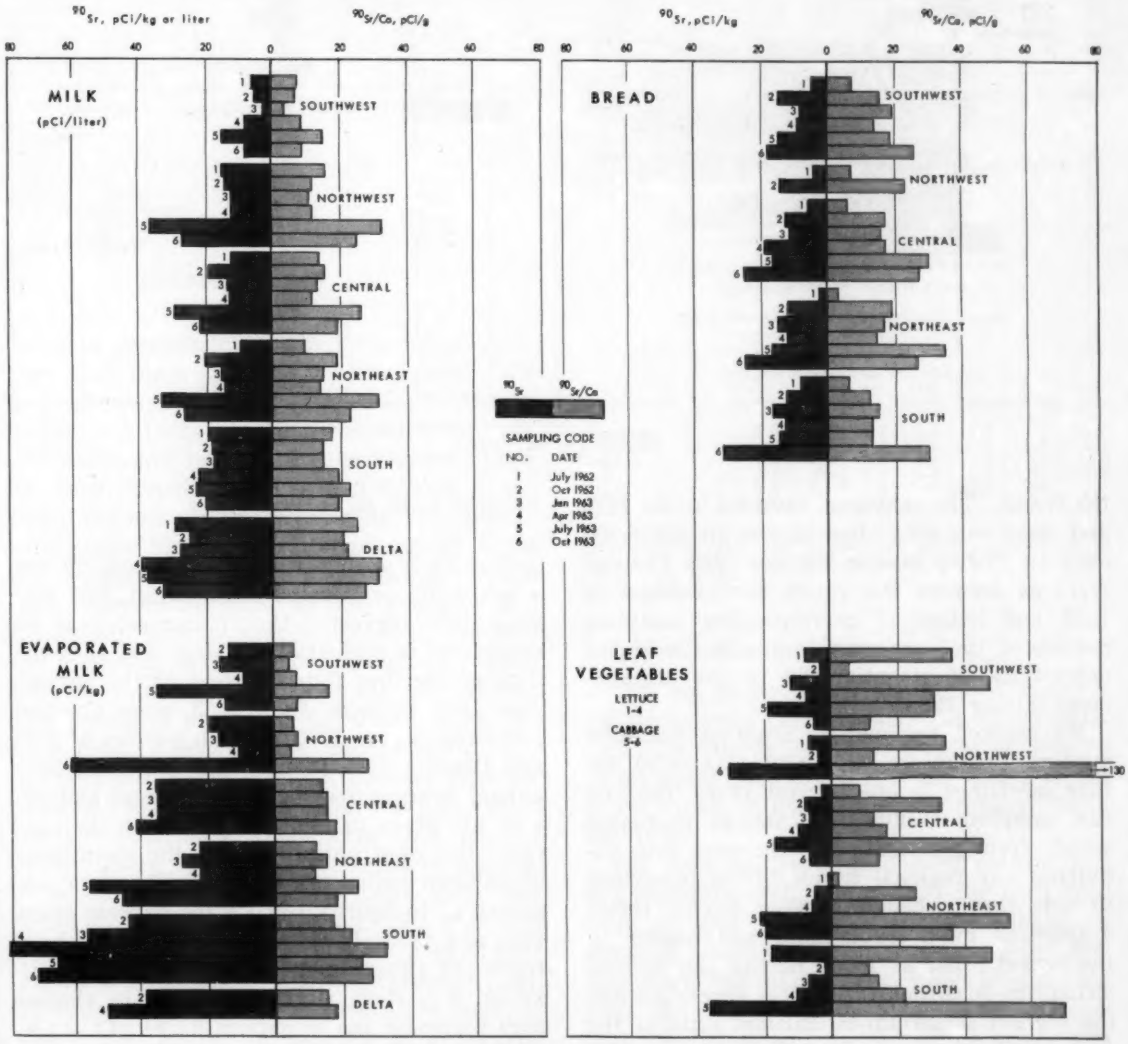

Figure 4. Regional distribution of strontium-90 and strontium-90/calcium in foods, July 1962–October 1963

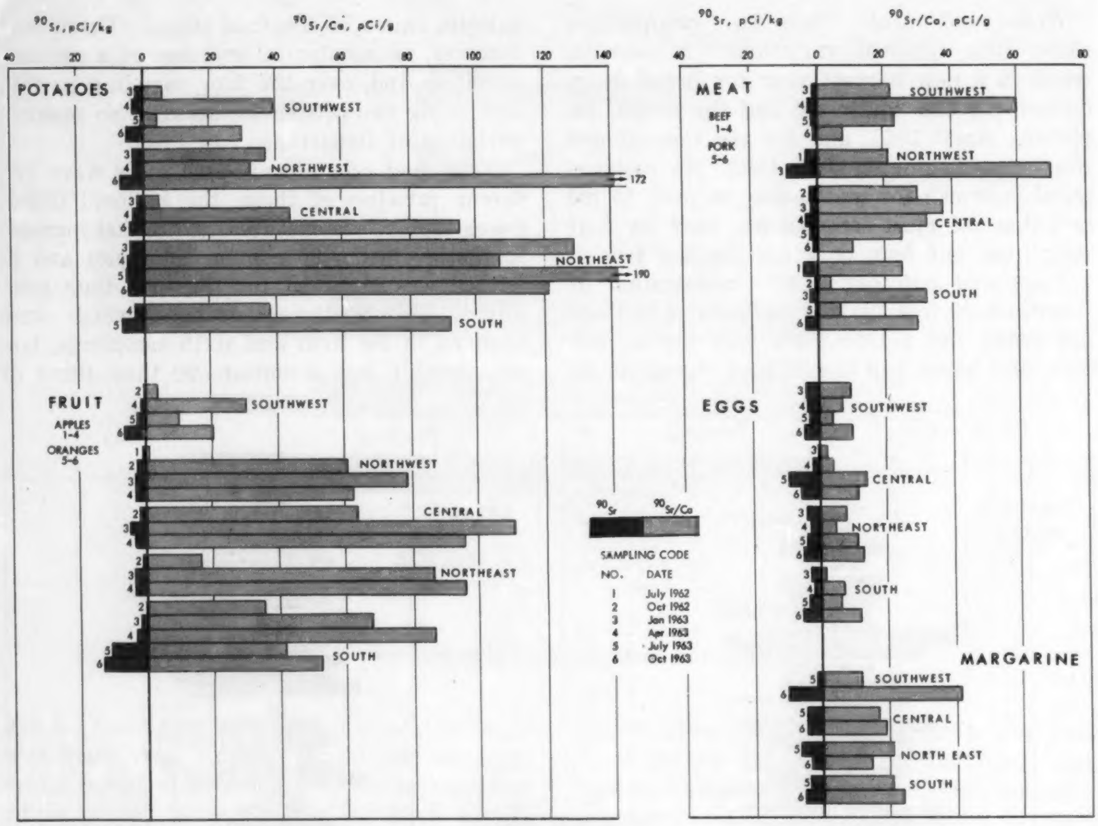

Figure 4—Continued

the South. The cabbages, sampled in the fifth and sixth samplings had higher strontium–90 contents in July than in October 1963. The differences between the values for cabbages in 1963 and lettuce in corresponding sampling periods of 1962 are consistent with the higher depositions of strontium–90 in the environment during 1963.

No marked regional or seasonal variation appears for lettuce, which was sampled for four samplings in one harvest year. The last two sampling results for cabbage fluctuated widely from one location to the next, thus obscuring any regional trends. It is important to note that although ranking fourth (after evaporated milk, whole milk and bread) in the survey's list of foods having the highest strontium–90 concentration, leaf vegetables had the highest strontium–90/calcium ratio of the first four foods.

Strontium–90 in harvest years

The 1963 spring rise in strontium–90 for whole milk, evaporated milk, bread, and leaf vegetables suggested that a harvest year be considered in evaluating the data. For this, the data of the first four quarters of the survey, July 1962 through April 1963, were grouped into harvest year 1962, and the samples of July and October 1963 in harvest year 1963. The annual average results for each food and region are given in tables 2 and 3 for the concentration of strontium–90 and the strontium–90/calcium ratio, respectively. The data are presented in figures 5 and 6 for harvest years 1962 and 1963. In these figures, the solid bars represent strontium–90 concentration in pCi/kg or, for whole milk, pCi/liter; the shaded bars represent the strontium–90 as pCi/g Ca.

The ascending order of regional magnitude

Table 2. Strontium-90 in foods by harvest year and region [a]

(pCi/kg)

Food item	United States	Southwest	Northwest	Central	Northeast	South	Delta
Harvest year 1962							
Evaporated milk	28.2	[b]13.5	[b]15.8	[b]35.7	[b]24.3	[b]60.2	[c]44.0
Reconstituted [d]	14.2	6.8	8.0	18.0	12.3	30.4	22.2
Whole milk [e]	16.3	6.6	14.4	15.4	16.0	19.9	31.0
Bread	11.1	9.6	[c]9.0	13.7	[c]13.5	11.6	NS
Lettuce	7.4	7.2	[c]5.7	7.1	[b]2.5	9.2	NS
Apples	2.1	0.4	2.4	2.6	1.7	1.5	NS
Eggs	2.9	[c]4.2	NS	1.7	3.7	2.0	NS
Beef	1.6	1.0	NS	1.4	NS	[b]2.2	NS
Potatoes	3.0	[c]2.5	[c]3.0	[c]2.2	[c]4.2	[f]3.0	NS
Oleomargarine	2.2	[c]5.5	NS	[c]4.0	[c]4.5	[c]4.2	NS
Harvest year 1963 [c]							
Evaporated milk	48.7	25.5	[f]61.5	[f]42.0	50.5	70.5	NS
Reconstituted [d]	25.6	13.4	32.3	22.1	26.5	37.0	NS
Whole milk [e]	28.1	12.5	32.7	26.7	30.5	22.7	36.0
Bread	18.9	16.2	NS	20.7	20.7	22.5	NS
Cabbage	18.8	11.7	[f]33.0	11.7	20.7	[f]36.5	NS
Oranges	8.1	4.2	NS	NS	NS	12.0	NS
Eggs	5.4	3.8	NS	7.7	4.5	4.0	NS
Pork meat	1.8	1.5	NS	1.0	NS	2.0	NS
Potatoes	4.9	[f]3.2	[f]6.5	4.0	5.0	[f]6.5	NS
Cereal (bran)	51.0	NS	NS	NS	NS	NS	NS

[a] All samples are for four quarters in 1962 and two quarters in 1963, except as noted.
[b] Sampled three quarters.
[c] Sampled two quarters.
[d] Reconstituted to calcium content of whole milk.
[e] pCi per liter.
[f] Sampled one quarter.
NS, no sample collected.

Table 3. Strontium-90/calcium ratio in food by harvest year and region [a]

(pCi/g Ca)

Food item	United States average	Southwest	Northwest	Central	Northeast	South	Delta
Harvest year 1962							
Evaporated milk	13.8	[b]5.0	[b]5.3	[b]15.7	[b]13.5	[b]25.2	[c]18.0
Whole milk	14.4	5.7	12.2	13.4	13.9	16.5	24.8
Bread	13.3	13.8	[c]14.5	13.5	13.4	11.8	NS
Lettuce	22.1	30.6	[c]24.2	17.6	[b]14.2	24.0	NS
Apples	44.5	8.4	50.8	67.2	49.1	47.2	NS
Eggs	5.3	[c]8.0	NS	3.0	6.2	4.2	NS
Beef	19.1	20.5	NS	31.0	NS	[b]15.5	NS
Potatoes	47.8	[c]22.5	[c]34.7	[c]24.5	[c]119.0	[d]38.0	NS
Oleomargarine	21.5	27.0	NS	18.0	18.2	22.7	NS
Harvest year 1963 [e]							
Evaporated milk	21.4	11.0	[d]28.0	[d]18.5	21.7	28.0	NS
Whole milk	23.0	11.0	28.0	22.7	26.5	20.5	29.2
Bread	26.0	22.0	NS	28.7	31.2	22.2	NS
Cabbage	30.3	22.0	[c]130.0	30.2	46.0	[d]69.5	NS
Oranges	30.8	15.2	NS	NS	NS	46.5	NS
Eggs	10.0	7.0	NS	12.5	12.0	8.5	NS
Pork meat	17.1	15.5	NS	17.7	NS	18.2	NS
Potatoes	87.5	[d]17.5	[d]77.0	95.0	156.0	[d]92.0	NS

[a] Sampled for four quarters in 1962 and for two quarters in 1963 except as noted.
[b] Sampled three quarters.
[c] Sampled two quarters.
[d] Sampled one quarter.
[e] Only two samples in one quarter. These were excluded from the U.S. average.
NS, no sample collected.

for both concentration and strontium-90/calcium ratio for whole milk in harvest year 1962 is Southwest, Northwest, Central, Northeast, South, and Delta. In 1963 the concentrations and ratios are higher, but the regional order has been altered somewhat, and differences between regions are less pronounced. The Southwest region has the lowest strontium-90 levels and strontium-90/calcium ratios for whole milk, evaporated milk, apples, oranges, and cabbage in both harvest years. It is also lowest for bread and eggs in harvest year 1963, but the regional differences for the harvest year averages are small for bread, eggs, lettuce, meat, oleomargarine, and potatoes.

The ratio of the average harvest year results in 1963 to those in 1962 was determined for the five foods common to both harvest years. These ratios are presented in table 4. It is of interest that the median ratio was found to be 1.8 for each food. The high and low ratios of from 0.9 to 4.6 for a particular region usually appear where the concentration of strontium-90 was low, such as in eggs, or where the number of samples in a regional group was small and consequently, less likely to be representative of the mean.

Table 4. Strontium-90 in 1963 harvest as compared to 1962 harvest

(Using average of strontium-90 concentrations and strontium-90/calcium ratios)

Food	Southwest	Northwest	Central	Northeast	South	Delta	Median
Evaporated milk	2.0	4.6	1.2	1.8	1.1		1.8
Whole milk	1.9	2.3	1.7	1.9	1.2	1.2	1.8
Bread	1.6	NS	1.8	1.9	1.9	NS	1.8
Eggs	0.9	NS	4.3	1.6	2.0	NS	1.8
Potatoes	1.0	2.2	1.8	1.25	2.3	NS	1.8

NOTE: The foods listed were common to both harvest years. Those 1963/1962 strontium-90 ratios of food types for the U.S. which are not common are as follows: oranges to apples, 2.0; cabbage to lettuce, 2.0; and pork meat to beef, 1.0.
NS, no sample collected.

Summary and conclusions

This report summarizes results of analyses for strontium-90 in foods sampled for six quarters. The survey included samples of 5 to 10 staple foods collected during the first 2 weeks of each quarter from July 1962 through October 1963.

The data on the strontium-90 content and the strontium-90/calcium ratio for each food were grouped into six broad geographical regions of production insofar as possible, irrespective of the market from which it was sampled. An estimate of the strontium-90 concentrations and strontium-90/calcium ratios was derived from the mean and median values for each region.

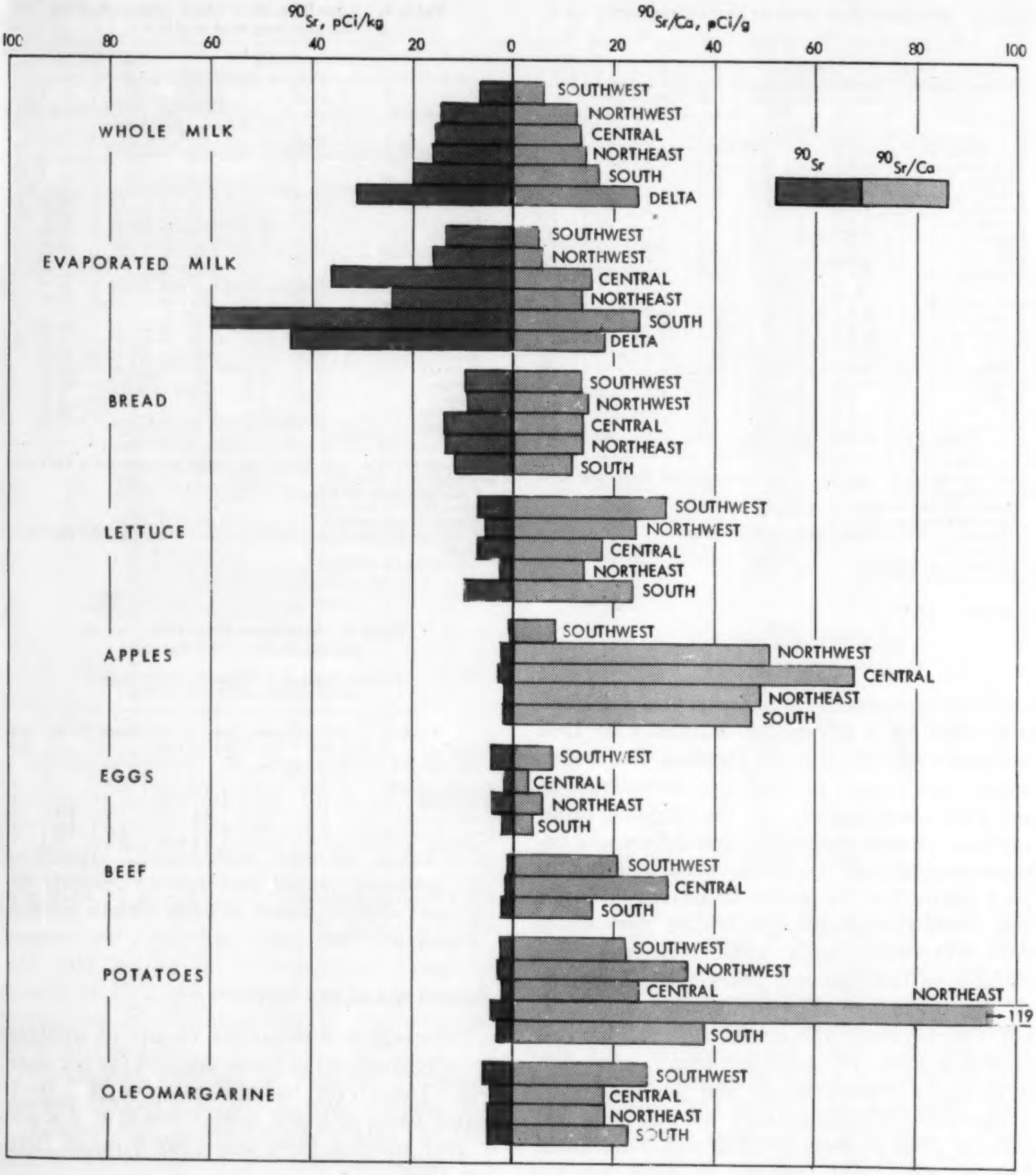

Figure 5. Regional distribution of strontium-90 in harvest year 1962 (samples of July 1962 through April 1963)

Examination of the strontium-90 concentrations and strontium-90/calcium ratios of the foods sampled suggests that whole milk provides a conservative index for estimating strontium-90 intake, unless an inordinately unbalanced food selection is made. Whole milk and evaporated milk tend to give regional differences and observable trends in a 3- or 6-month period; bread shows similar but less pronounced trends. Regional trends in strontium-90 were least discernible for potatoes, eggs, meat, fruit, and oleomargarine, due in part to

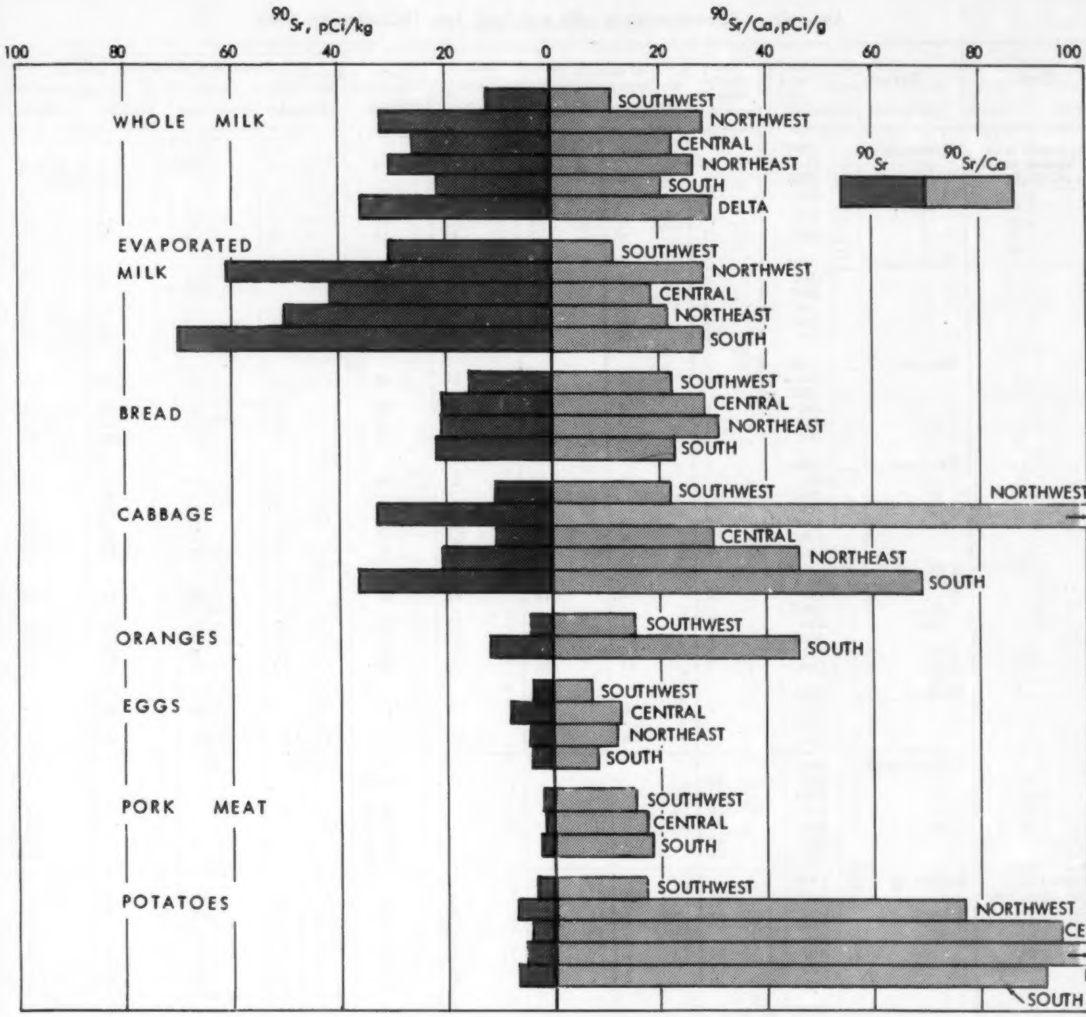

Figure 6. Regional distribution of strontium-90 in harvest year 1963 (samples of July-October 1963)

the low strontium-90 content per unit weight and presumably to interegional shipment of food and feed. Foods such as cabbage, potatoes, and fruit had low strontium-90 concentrations; strontium-90/calcium ratios are somewhat greater than those for whole milk and evaporated milk.

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Appendix. Strontium-90 in milk and food, July 1962–October 1963

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Evaporated milk (Concentration in pCi/kg)	Southwest	1962									
		Oct	10	7	23	14	14	3	9	5	5
		1963									
		Jan	10	4	23	19	15	1	9	7	5
		Apr	9	2	19	10	9	1	5	4	4
		July	10	17	64	35	37	7	27	15	16
		Oct	7	0	37	15	15	0	9	6	7
	Northwest	1962									
		Oct	4	2	61	20	20	1	22	3	7
		1963									
		Jan	1	—	—	—	17	—	—	—	7
		Apr	3	10	14	10	11	4	5	4	4
		Oct	3	23	71	70	53	20	29	29	27
	Central	1962									
		Oct	16	15	92	35	38	6	36	14	16
		1963									
		Jan	8	17	59	35	36	7	25	16	16
		Apr	11	19	61	31	39	10	24	15	17
		Oct	3	0	65	47	37	0	27	20	17
	Northeast	1962									
		Oct	4	14	40	21	24	6	18	12	12
		1963									
		Jan	6	14	33	30	27	8	17	16	15
		Apr	5	18	25	22	22	11	14	13	13
		July	8	27	94	55	57	11	36	26	23
		Oct	8	21	85	43	49	9	35	18	20
	South	1962									
		Oct	10	6	78	44	43	3	30	19	18
		1963									
		Jan	10	27	78	55	57	15	33	22	24
		Apr	3	48	110	82	80	27	42	33	35
		July	7	26	122	64	66	11	49	26	27
		Oct	7	47	135	62	80	22	52	26	33
	Delta	1962									
		Oct	4	16	64	36	41	7	24	16	17
		1963									
		Apr	3	28	80	46	54	11	33	18	21
	United States	1962									
		Oct	48				32.2				13.1
		1963									
		Jan	35				33.8				14.5
		Apr	34				31.2				13.3
		July	25				51.7				22.0
		Oct	28				45.7				22.0
Milk, fluid (Concentration in pCi/liter)	Southwest	1962									
		July	13	3	21	5	9	2	20	4	9
		Oct	7	2	11	5	6	2	9	6	5
		1963									
		Jan	7	2	12	2	5	2	9	2	4
		Apr	14	3	33	7	12	3	27	6	10
		July	14	2	42	15	17	2	35	13	15
		Oct	10	2	20	8	10	2	16	7	9
	Northwest	1962									
		July	10	13	21	16	16	12	20	14	16
		Oct	9	11	25	15	16	8	19	11	11
		1963									
		Jan	6	11	16	13	13	8	13	9	11
		Apr	12	9	17	13	13	7	13	11	11
		July	12	29	59	39	37	24	49	32	32
		Oct	11	17	37	29	27	14	32	24	24
	Central	1962									
		July	24	4	30	12	15	3	28	13	14
		Oct	25	13	31	21	20	10	23	15	15
		1963									
		Jan	22	8	28	14	14	7	16	12	14
		Apr	30	8	22	13	14	6	21	11	12
		Jul	30	19	67	29	32	19	67	25	27
		Oct	29	13	54	21	25	11	47	18	21
	Northeast	1962									
		July	27	4	25	10	11	3	22	8	10
		Oct	27	10	32	22	23	10	26	18	19
		1963									
		Jan	28	10	24	16	16	9	21	14	15
		Apr	29	10	26	14	16	9	22	13	14
		July	30	26	57	36	32	22	46	30	32
		Oct	30	20	41	27	27	16	34	22	22
	South	1962									
		July	10	5	31	20	19	14	26	17	17
		Oct	12	9	28	19	18	8	23	14	15
		1963									
		Jan	23	10	26	18	18	8	21	15	15
		Apr	24	12	32	24	23	10	25	20	19
		July	23	8	48	22	26	7	47	21	23
		Oct	22	16	33	20	23	14	28	18	20

Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Milk, fluid —Continued	Delta	1962									
		July	7	24	37	30	30	19	31	25	25
		Oct	7	18	33	25	25	15	26	20	20
		1963									
		Jan	7	24	30	30	27	18	21	15	15
		Apr	8	34	46	40	40	27	25	20	19
		July	8	32	41	38	38	27	33	31	31
		Oct	8	26	38	34	33	22	31	28	27
	United States	1962									
		July	91				14.7				13.5
		Oct	87				19.0				15.4
		1963									
		Jan	93				16.2				14.2
		Apr	117				17.8				15.1
		July	117				31.8				27.3
		Oct	110				24.5				32.1
Bread (Concentration in pCi/kg)	Southwest	1962									
		July	8	2	10	5	5	2	16	6	7
		Oct	10	0	24	17	14	0	28	16	16
		1963									
		Jan	13	0	87	7	15	0	145	14	24
		Apr	15	0	16	10	9	0	20	14	13
		July	12	5	27	16	15	4	26	18	18
		Oct	11	0	35	20	17	2	62	27	25
	Northwest	1962									
		July	9	3	18	3	5	3	26	5	8
		Oct	4	9	23	13	15	10	36	22	23
	Central	1962									
		July	13	2	11	6	7	1	14	5	6
		Oct	20	2	59	11	15	1	151	12	21
		1963									
		Jan	10	10	26	16	17	9	32	15	16
		Apr	10	4	28	19	19	3	33	16	17
		July	20	10	32	15	18	11	100	33	27
		Oct	20	0	47	25	25	0	61	29	26
	Northeast	1962									
		July	10	0	8	3	3	0	9	3	3
		Oct	5	6	22	11	13	4	29	20	18
		1963									
		Jan	10	3	23	15	15	3	29	18	16
		Apr	10	7	21	11	13	6	40	15	14
		July	11	10	27	15	18	23	96	35	36
		Oct	7	5	34	26	24	6	68	26	28
	South	1962									
		July	16	0	19	8	8	0	15	6	8
		Oct	11	8	21	12	12	6	19	12	12
		1963									
		Jan	11	7	24	17	15	6	28	15	15
		Apr	10	7	21	12	13	6	22	14	12
		July	12	4	28	14	14	3	28	13	14
		Oct	15	17	48	31	31	19	48	30	32
	Delta	1962									
		July	5	0	7	0	2	0	6	0	3
	United States	1962									
		July	61				5.6				6.2
		Oct	50				13.9				17.9
		1963									
		Jan	44				15.5				17.4
		Apr	45				13.2				13.8
		Jul	55				16.5				21.9
		Oct	53				21.3				23.7
Lettuce (Concentration in pCi/kg)	Southwest	1962									
		July	8	0	38	4	11	0	90	30	44
		Oct	9	0	10	2	4	0	30	3	9
		1963									
		Jan	15	0	66	8	15	0	140	41	56
		Apr	6	0	15	7	7	0	50	30	32
	Northwest	1962									
		July	5	3	10	7	7	23	47	35	36
		Oct	4	0	19	2	6	0	61	7	19
	Central	1962									
		July	16	0	8	3	3	0	20	7	9
		Oct	6	2	20	8	9	12	59	32	34
		1963									
		Jan	6	3	18	6	8	4	25	12	13
		Apr	4	0	15	11	9	0	19	18	16
	Northeast	1962									
		July	10	0	3	0	1	0	11	0	4
		Oct	6	0	15	5	5	0	100	19	32
		1963									
		Apr	1	—	—	—	6	—	—	—	15

Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Lettuce–Continued	South	1962									
		July	1	—	—	—	18	—	—	—	48
		Oct	1	—	—	—	2	—	—	—	11
		1963									
		Jan	3	0	8	8	5	0	20	13	16
		Apr	4	3	15	11	10	14	30	22	23
	United States	1962									
		July	40				4.5				19.1
		Oct	26				5.9				22.1
		1963									
		Jan	24				11.9				33.2
		Apr	15				8.3				21.8
Cabbage (Concentration in pCi/kg)	Southwest	1963									
		July	4	0	40	20	17	0	70	26	38
		Oct	6	0	17	4	6	0	41	10	14
	Northwest	1963									
		Oct	2	24	43	33	33	126	134	130	130
	Central	1963									
		July	4	2	31	17	17	5	89	50	42
		Oct	11	0	17	6	7	0	41	13	16
	Northeast	1963									
		July	11	5	80	20	23	23	143	48	60
		Oct	13	2	52	19	21	5	149	34	42
	South	1963									
		July	5	8	72	39	35	20	157	76	63
	United States	1963									
		July	24				23.5				54.0
		Oct	32				14.1				31.8
Waste		1963									
		July	6	38	208	94	106	64	246	170	147
		Oct	8	15	122	56	57	17	130	36	53
Apples (Concentration in pCi/kg)	Southwest	1962									
		July	1	—	—	—	0	—	—	—	0
		Oct	5	0	2	0	<1	0	33	0	7
		1963									
		Jan	2	0	0	0	0	0	0	0	0
		Apr	2	0	3	1	2	0	60	30	30
	Northwest	1962									
		July	4	0	8	0	2	0	2	0	1
		Oct	4	0	14	1	.4	0	467	0	121
		1963									
		Jan	5	0	26	0	6	0	650	0	156
		Apr	6	0	22	1	5	0	314	20	104
	Central	1962									
		July	4	0	0	0	0	0	0	0	0
		Oct	15	0	4	2	2	0	133	67	60
		1963									
		Jan	8	2	9	5	5	50	225	100	121
		Apr	4	0	6	4	3	0	150	100	90
	Northeast	1962									
		July	2	0	0	0	0	0	0	0	0
		Oct	15	0	9	0	2	0	125	0	32
		1963									
		Jan	10	2	9	3	4	60	450	75	97
		Apr	10	0	11	3	4	0	275	83	106
	South	1962									
		July	2	0	0	0	0	0	0	0	0
		Oct	8	0	3	0	1	0	100	33	38
		1963									
		Jan	4	2	2	2	2	50	100	67	67
		Apr	3	0	4	4	3	0	100	100	73
	United States	1962									
		July	13				0.6				1.5
		Oct	47				1.8				47.0
		1963									
		Jan	29				3.9				102.0
		Apr	25				3.5				92.0
Oranges (Concentration in pCi/kg)	Southwest	1963									
		July	12	0	9	2	3	0	19	10	10
		Oct	9	0	45	4	9	0	115	12	29
	South	1963									
		July	2	11	11	11	11	30	52	41	41
		Oct	2	6	19	13	13	14	90	52	52
	United States	1963									
		July	14				4.1				14.0
		Oct	11				10.0				31.0
Waste		1963									
		July	8	6	46	13	18	4	54	12	14
		Oct	3	16	75	30	40	5	14	50	34

Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Eggs (Concentration in pCi/kg)	Southwest	1963									
		Jan	8	2	34	2	7	4	72	5	13
		Apr	12	0	26	3	5	0	53	5	9
		July	4	0	5	3	3	0	9	3	5
		Oct	5	3	6	5	4	6	13	10	10
	Central	1963									
		Jan	6	0	5	0	1	4	72	5	13
		Apr	6	0	3	3	2	0	53	5	9
		July	8	0	37	8	11	0	64	16	12
		Oct	6	3	8	6	6	8	15	11	11
	Northeast	1963									
		Jan	7	2	7	4	4	4	13	7	8
		Apr	6	0	4	3	3	0	7	5	5
		July	9	3	8	4	4	6	21	11	11
		Oct	8	3	8	5	5	9	17	13	13
	South	1963									
		Jan	6	0	5	3	2	0	10	0	3
		Apr	3	0	3	2	2	0	7	7	7
		July	5	0	4	3	3	0	8	6	5
		Oct	6	0	13	5	5	0	21	11	12
	United States	1963									
		Jan	27				3.9				8.6
		Apr	27				3.3				6.8
		July	26				5.7				10.9
		Oct	25				5.2				11.4
Beef (Concentration in pCi/kg)	Southwest	1962									
		July	3	0	0	0	0	0	0	0	0
		Oct	2	0	0	0	0	0	0	0	0
		1963									
		Jan	4	0	4	1	2	0	57	17	26
		Apr	4	2	6	2	3	50	120	50	71
	Northwest	1962									
		July	2	0	4	2	2	0	44	22	22
		1963									
		Jan	1	—	—	—	9	—	—	—	69
	Central	1962									
		July	3	0	0	0	0	0	0	0	0
		Oct	7	0	4	2	2	0	67	33	27
		1963									
		Jan	6	0	5	2	2	0	83	38	37
		Apr	8	0	6	3	3	0	67	33	31
	South	1962									
		July	5	0	7	3	5	0	41	25	26
		Oct	5	0	4	0	1	0	33	0	7
		1963									
		Jan	2	0	4	2	2	0	57	33	33
	United States	1962									
		July	13				1.4				13.4
		Oct	14				1.3				16.0
		1963									
		Jan	13				2.5				38.5
		Apr	12				2.8				26.3
Pork (Concentration in pCi/kg)	Southwest	1963									
		July	3	0	4	2	2	0	33	25	21
		Oct	2	0	2	1	1	0	17	8	8
	Central	1963									
		July	11	0	4	2	2	0	200	20	29
		Oct	15	0	8	0	1	0	160	0	22
	South	1963									
		July	7	0	6	0	1	0	32	0	13
		Oct	8	0	16	3	4	0	145	22	38
	United States	1963									
		July	21				2.0				21.5
		Oct	25				2.0				26.7
Waste bone		1963									
		July	9	308	1,480	566	693	4	34	15	13
		Oct	13	260	811	460	525	3	17	8	9

Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90 Minimum	Strontium-90 Maximum	Strontium-90 Median	Strontium-90 Mean	Strontium-90/calcium (pCi/g) Minimum	Strontium-90/calcium (pCi/g) Maximum	Strontium-90/calcium (pCi/g) Median	Strontium-90/calcium (pCi/g) Mean
Potatoes (Concentration in pCi/kg)	Southwest	1963									
		Jan	2	0	4	2	2	0	8	4	8
		Apr	4	2	5	3	3	15	71	42	36
		July	16	0	6	0	1	0	150	0	9
		Oct	4	0	12	5	5	0	60	32	29
	Northwest	1963									
		Jan	5	0	5	3	3	0	71	37	37
		Apr	4	2	4	3	3	28	38	33	32
		Oct	7	0	25	5	8	0	420	50	104
	Central	1963									
		Jan	3	0	2	2	1	0	33	4	7
		Apr	9	0	7	3	3	0	175	40	47
		Oct	12	2	8	4	4	0	200	100	90
	Northeast	1963									
		Jan	8	3	5	4	4	80	200	141	121
		Apr	8	3	9	4	5	67	167	100	115
		July	6	0	24	4	6	0	800	184	195
		Oct	10	2	9	4	5	33	700	125	120
	South	1963									
		Apr	2	2	3	3	3	33	43	38	38
		July	9	4	10	6	7	13	700	120	65
	United States	1963									
		Jan	18				2.9				30.0
		Apr	27				3.6				54.0
		July	31				3.6				43.0
		Oct	33				5.3				78.0
Waste		1963									
		July	9	2	17	.10	11	50	1,000	106	117
		Oct	5	5	16	12	12	17	123	92	69
Oleomargarine (Concentration in pCi/kg)	Southwest	1963									
		Jan	7	0	3	0	1	0	200	4	20
		Apr	6	6	16	10	10	22	67	44	40
	Central	1963									
		Jan	3	3	4	4	4	14	21	17	17
		Apr	9	2	6	4	4	0	25	19	19
	Northeast	1963									
		Jan	8	2	12	6	6	10	54	17	26
		Apr	4	2	4	3	3	12	18	15	15
	South	1963									
		Jan	11	0	7	4	3	0	300	21	21
		Apr	8	0	11	5	5	0	50	22	27
	United States	1963									
		Jan	29				3.4				22.5
		Apr	27				5.4				19.5
Cereal											
Corn		1963									
		July	8	0	6	3	3	0	200	32	20
		Oct	7	2	35	6	15	50	1,033	115	131
Wheat		1963									
		July	9	20	110	52	62	80	447	162	195
		Oct	10	27	156	110	99	44	495	230	223
Oats		1963									
		July	4	0	25	23	14	0	125	29	10
		Oct	4	7	83	42	43	5	117	42	30
Rice		1963									
		July	8	0	25	10	12	0	42	23	29
		Oct	5	2	18	7	8	11	120	32	45
Wheat, malted		1963									
		July	3	48	74	66	63	114	211	183	160
		Oct	2	95	140	118	118	352	425	390	390
Bran		1963									
		July	2	88	187	128	128	196	220	108	208
		Oct	4	19	430	68	146	25	377	100	179
Small grain[a]		1963									
		July	26				45				83
		Oct	25				82				138
	United States	1963									
		July	34				35				68
		Oct	32				67				136

[a] Summary of all grains except corn.

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. For milk, routine sampling has been defined as one or more samples collected per month.

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. Data from the Pasteurized Milk Network (U.S.), Canadian Milk Network and Pan American Milk Network are presented below.

1. Pasteurized Milk Network October 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*6*).

The results for October 1965 and third quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*6*), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for May through October 1965 and October 1964. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

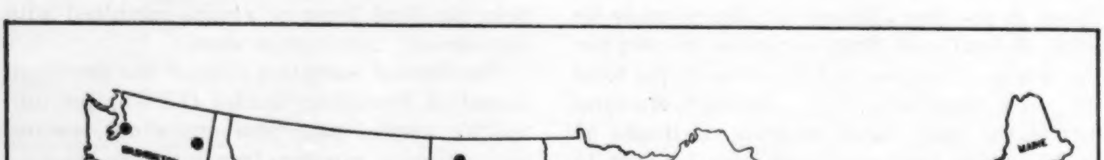

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the third quarter and October 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Third quarter	October	Third quarter	October	Third quarter	October	Third quarter	October
Ala:	Montgomery	1.14	1.17	<5	<5	14	15	40	30
Alaska:	Palmer	1.22	1.41	<5	<5	15	12	50	50
Ariz:	Phoenix	1.22	1.24	<5	<5	4	3	20	10
Ark:	Little Rock	1.14	1.19	5	<5	28	28	50	30
Calif:	Sacramento	1.28	1.28	<5	<5	5	4	25	10
	San Francisco	1.25	1.27	<5	<5	5	3	20	15
C. Z:	Cristobal	1.10	1.14	<5	<5	4	13	30	35
Colo:	Denver	1.28	1.28	<5	<5	14	13	40	25
Conn:	Hartford	1.09	1.11	<5	<5	13	13	50	40
Del:	Wilmington	1.11	1.14	<5	<5	15	16	40	30
D. C:	Washington	1.13	1.13	<5	<5	13	13	30	20
Fla:	Tampa	1.16	1.16	<5	<5	12	13	175	150
Ga:	Atlanta	1.14	1.16	<5	<5	20	19	55	45
Hawaii:	Honolulu	1.16	1.16	<5	<5	6	8	40	40
Idaho:	Idaho Falls	1.27	1.26	<5	<5	16	12	50	40
Ill:	Chicago	1.11	1.13	<5	<5	11	12	35	35
Ind:	Indianapolis	1.11	1.16	<5	<5	12	12	25	25
Iowa:	Des Moines	1.23	1.25	<5	<5	16	15	30	20
Kans:	Wichita	1.19	1.23	<5	<5	14	14	25	20
Ky:	Louisville	1.12	1.14	5	<5	18	18	25	20
La:	New Orleans	1.18	1.22	<5	<5	33	31	60	45
Maine:	Portland	1.11	1.14	5	<5	20	15	90	65
Md:	Baltimore	1.11	1.15	<5	<5	15	16	40	25
Mass:	Boston	1.10	1.13	5	<5	19	17	80	55
Mich:	Detroit	1.09	1.11	<5	<5	11	12	35	30
	Grand Rapids	1.13	1.16	<5	<5	14	15	45	40
Minn:	Minneapolis	1.28	1.26	5	<5	23	22	50	40
Miss:	Jackson	1.18	1.19	<5	<5	25	25	40	30
Mo:	Kansas City	1.21	1.21	5	<5	18	16	25	20
	St. Louis	1.22	1.23	5	<5	16	17	25	20
Mont:	Helena	1.27	1.32	5	<5	18	13	55	45
Nebr:	Omaha	1.22	1.20	<5	<5	16	16	30	30
Nev:	Las Vegas	1.20	1.33	<5	<5	5	4	20	25
N. H:	Manchester	1.11	1.14	<5	<5	21	10	105	70
N. J:	Trenton	1.09	1.12	<5	<5	14	11	40	30
N. Mex:	Albuquerque	1.24	1.22	<5	<5	6	4	20	20
N. Y:	Buffalo	1.09	1.10	<5	<5	11	11	45	40
	New York	1.09	1.10	<5	<5	17	15	55	35
	Syracuse	1.09	1.10	5	<5	12	12	40	30
N. C:	Charlotte	1.13	1.18	<5	<5	24	23	40	30
N. Dak:	Minot	1.28	1.30	10	<5	31	31	55	35
Ohio:	Cincinnati	1.11	1.16	<5	<5	13	14	25	20
	Cleveland	1.10	1.12	5	<5	13	13	35	25
Okla:	Oklahoma City	1.11	1.16	<5	<5	14	14	25	20
Ore:	Portland	1.28	1.26	<5	<5	14	12	50	40
Pa:	Philadelphia	1.08	1.12	<5	<5	13	13	35	30
	Pittsburgh	1.11	1.14	5	<5	20	17	50	35
P. R:	San Juan	1.13	1.12	<5	<5	9	10	40	35
R. I:	Providence	1.10	1.13	<5	<5	16	15	65	45
S. C:	Charleston	1.14	1.17	<5	<5	23	24	70	65
S. Dak:	Rapid City	1.04	1.23	10	<5	20	22	50	50
Tenn:	Chattanooga	1.16	1.22	<5	<5	26	23	40	35
	Memphis	1.15	1.18	5	<5	20	19	25	15
Tex:	Austin	1.12	1.17	<5	<5	5	6	20	15
	Dallas	1.11	1.16	<5	<5	12	13	25	20
Utah:	Salt Lake City	1.36	1.40	<5	<5	12	13	55	40
Vt:	Burlington	1.11	1.12	<5	<5	17	15	65	45
Va:	Norfolk	1.13	1.17	<5	<5	17	17	40	30
Wash:	Seattle	1.28	1.31	<5	<5	18	19	70	50
	Spokane	1.33	1.31	<5	<5	18	16	50	40
W. Va:	Charleston	1.12	1.17	<5	<5	18	17	25	25
Wis:	Milwaukee	1.17	1.21	<5	<5	11	13	40	40
Wyo:	Laramie	1.28	1.30	<5	<5	14	13	50	50
Network average		1.16	1.19	<5	<5	15.3	14.8	44	35

[a] All iodine-131 and barium-140 values were below detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pastuerized Milk Network Stations, May–October 1965 and October 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	May	June	July	Aug	Sep	Oct	Oct
Under 10	4	7	8	10	11	8	6
10–19	26	21	34	41	44	46	37
20–29	25	29	18	11	7	7	13
30–39	5	4	3	1	1	2	7
40–49	2	2	0	0	0	0	0
50–59	0	0	0	0	0	0	0
60–69	1	0	0	0	0	0	0
70–79	0	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, May–October 1965 and October 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	May	June	July	Aug	Sep	Oct	Oct
Under 50	17	19	34	45	50	54	16
50–99	31	38	25	16	12	8	40
100–149	13	5	3	1	0	0	6
150–199	2	1	1	1	1	1	0
200–249	0	0	0	0	0	0	1
250–299	0	0	0	0	0	0	0

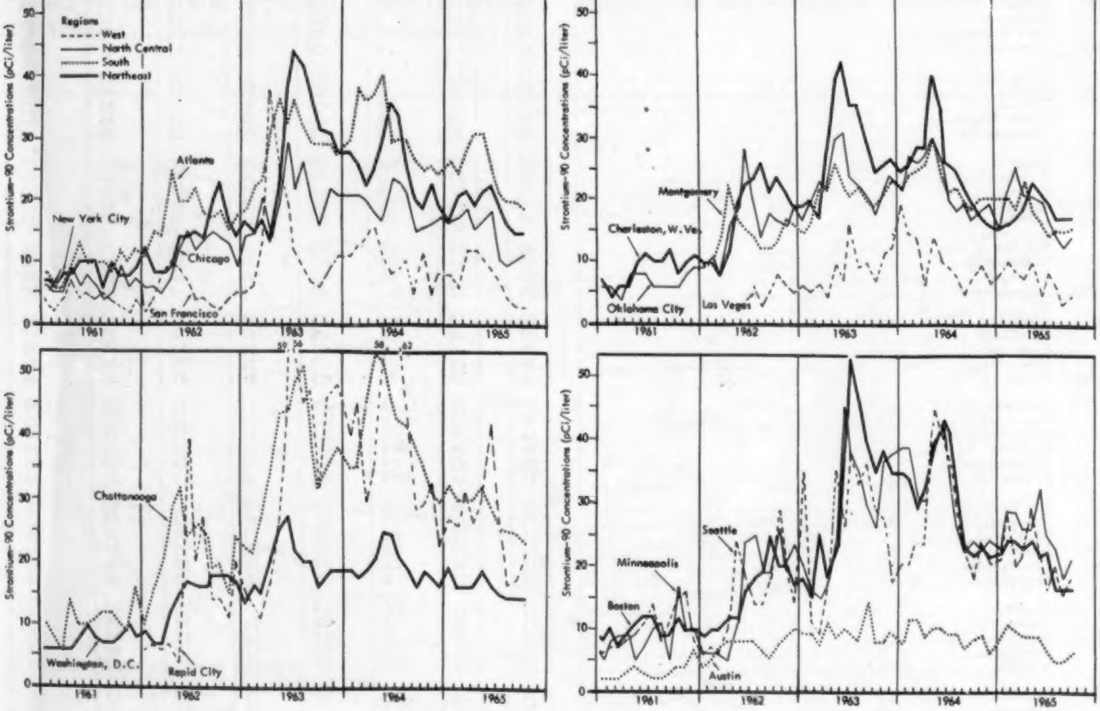

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–October 1965

2. Canadian Milk Network[1] October 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data (7).*

The October 1965 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from November 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 4. Stable elements and radionuclides in Canadian whole milk, October 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.4	16.7	63
Edmonton	1.14	1.4	19.8	54
Ft. William	1.12	1.6	28.1	82
Fredericton	1.12	1.6	30.8	73
Halifax	1.15	1.6	39.1	68
Montreal	1.09	1.6	16.6	42
Ottawa	1.14	1.6	13.7	38
Quebec	1.11	1.6	27.4	74
Regina	1.14	1.6	17.5	49
St. John's, Nfld	1.02	1.5	35.8	107
Saskatoon	1.14	1.6	20.1	41
Sault Ste. Marie	1.08	1.5	27.0	83
Toronto	1.13	1.6	7.6	32
Vancouver	1.20	1.6	23.0	101
Windsor	1.14	1.5	8.8	29
Winnipeg	1.08	1.6	18.4	62
Average	1.12	1.6	21.9	62

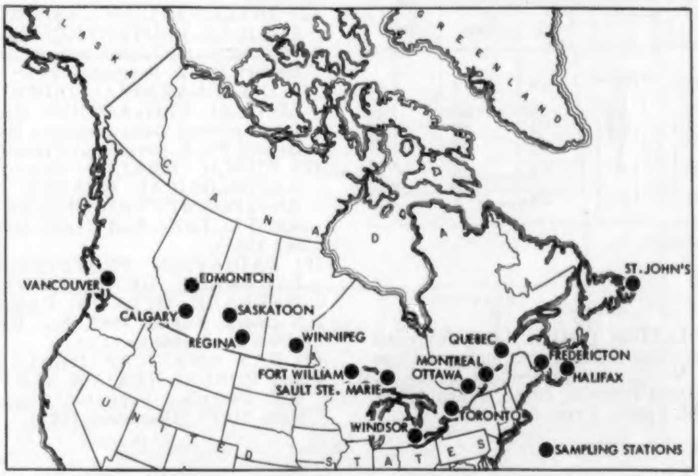

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program, October 1965

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries. Sampling locations are shown in figure 4. Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data (8)*.

Table 5 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

Figure 4. Pan American Milk Network sampling stations

Table 5. Stable element and radionuclide concentrations in PAHO milk, October 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.14	1.6	<5	5	35
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.12	1.6	<5	30	35
Venezuela:					
Caracas	1.23	1.45	<5	6	15

NS indicates no sample collected.

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(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 2. Superintendent of documents. U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965). Price 30 cents.

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press (1965).

(*6*) PUBLIC HEALTH SERVICE. DIVISION OF RADIOLOGICAL HEALTH AND DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Rad Health Data 6:667–681 (December 1965).

(*7*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*8*) PAN AMERICAN HEALTH ORGANIZATION, and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

The sampling and analysis for radionuclides in milk is an integral part of comprehensive environmental surveillance programs. A number of States have developed milk surveillance programs to satisfy their needs. While there is variation between programs, to a considerable extent the data produced complements that from Federal milk surveillance activities. Data from selected State milk surveillance activities are presented below. The results presented, while not all-inclusive, are representative of current State milk surveillance activities.

1. Connecticut Milk Network April–September 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium-89 and strontium-90 since April 1960. In May 1962 the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium-89, strontium-90, and gamma emitters. Concentrations of iodine-131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium-89 and strontium-90 are determined by chemical separation. Iodine-131 and cesium-137 are determined by gamma-scintillation spectroscopy.

The monthly average concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
April 1960–December 1962	*May 1963*
January 1963–December 1963	*September 1964*
January 1964–December 1964	*May 1965*
January 1965–March 1965	*August 1965*

Table 1. Radionuclide concentrations in central Connecticut milk, April–September 1965 [a]

Month, 1965	Concentration (pCi/liter)		
	Strontium-89	Strontium-90	Cesium-137
April	ND	15	80
May	ND	16	70
June	ND	13	40
July	ND	13	50
August	ND	14	50
September	ND	13	40

ND, below detectable levels.
[a] Iodine-131 concentrations were below detectable levels.

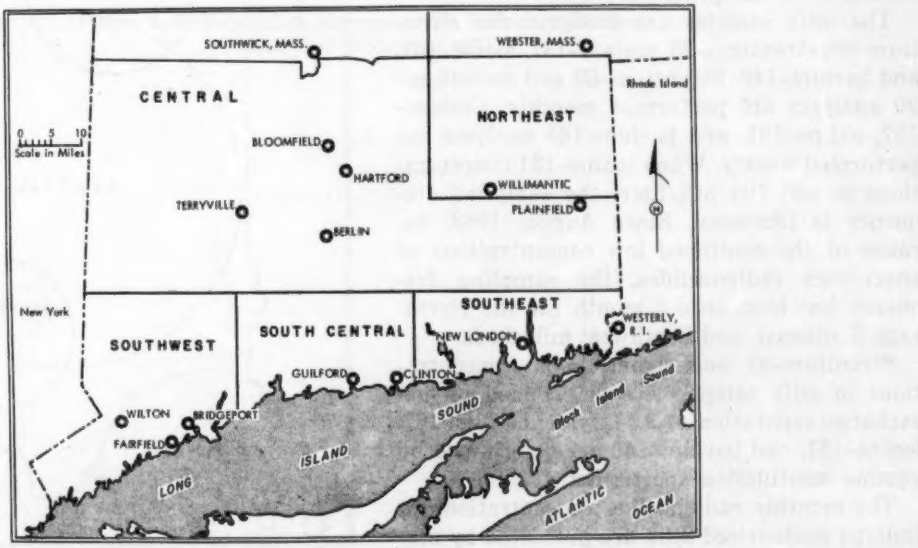

Figure 1. Connecticut pasteurized milk sampling areas

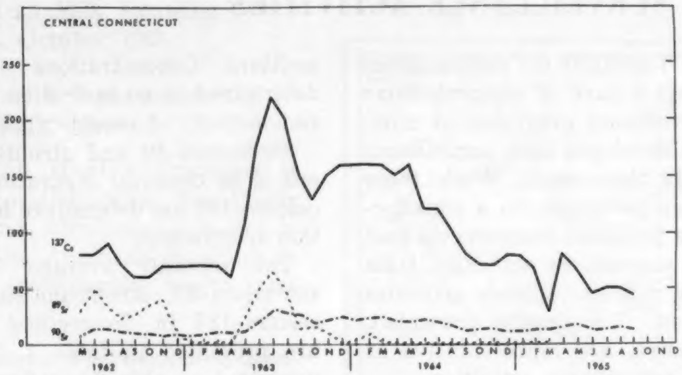

Figure 2. Radionuclide concentrations in Connecticut pasteurized milk, 1962–September 1965

2. Indiana Milk Network July–September 1965

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: Northeast, Northwest, Central, Southeast, and Southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed for strontium–89, strontium–90, cesium–137, iodine–131, and barium–140. Strontium–89 and strontium–90 analyses are performed monthly. Cesium–137, iodine–131, and barium–140 analyses are performed weekly. When iodine–131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency has been once a month for the Northeast, Southeast, and Southwest milksheds.

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*1,2,3*), while cesium–137, iodine–131, and barium–140 are determined by gamma scintillation spectrometry.

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 2 for July through September 1965. The monthly concentrations of iodine–131 and barium–140 remained below limits of detectability.

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 4.

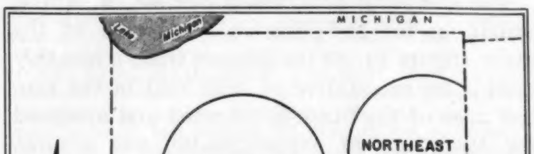

Figure 3. Indiana pasteurized milk sampling areas

Table 2. Radionuclides in Indiana milk, July–September 1965

Sampling locations	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
Northeast	1.13	1.13	1.14	1,340	1,330	1,380	9	12	13	25	30	30
Southeast	1.13	NS	1.13	1,430	NS	1,410	17	NS	14	25	NS	25
Central	1.13	1.13	1.13	1,360	1,360	1,340	11	12	10	25	25	25
Southwest	1.13	1.15	1.13	1,330	1,420	1,360	14	20	16	30	20	15
Northwest	1.13	1.13	1.13	1,380	1,360	1,360	10	15	13	40	35	30
Average	1.13	1.14	1.13	1,370	1,370	1,370	12	15	13	30	30	25

NS, no sample collected.

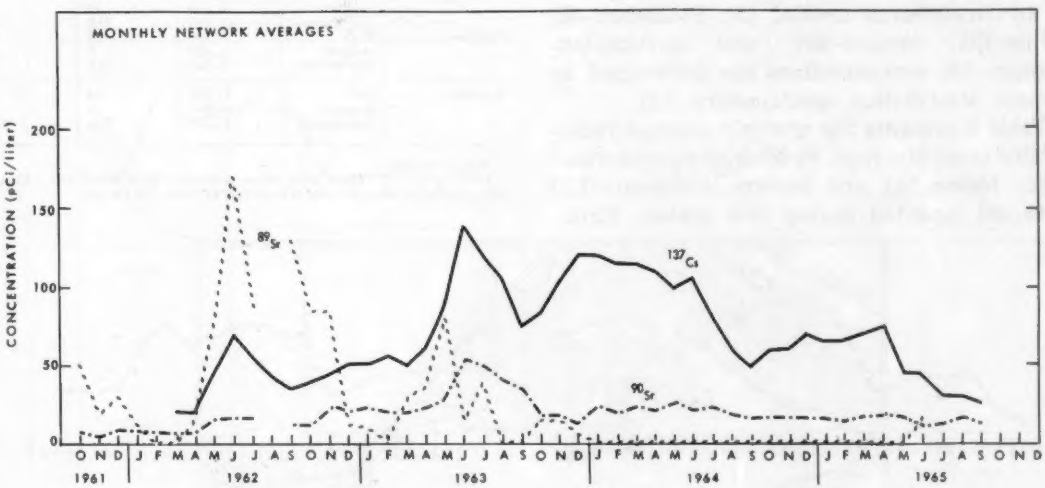

Figure 4. Radionuclide concentrations in Indiana pasteurized milk, 1961–September 1965

3. Michigan Milk Network July–September 1965

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (see figure 5). Milkshed samples are composites from dairies, in proportion to sales volumes.

Strontium–90 concentrations are determined by an ion exchange method (*2*). Potassium–40, iodine–131, cesium–137, and barium–lanthanum–140 concentrations are determined by gamma scintillation spectrometry (*4*).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Iodine–131 and barium–lanthanum–140 were not detected during this period. Strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to show general trends.

Table 3. Radionuclides in Michigan pasteurized milk[a] July–September 1965, pCi/liter

Station	Month, 1965	Potassium-40	Strontium-90	Cesium-137
Charlevoix	July	1,350	24	59
	August	1,330	17	41
	September	1,320	NA	38
Detroit	July	1,310	14	34
	August	1,320	11	27
	September	1,350	NA	24
Grand Rapids	July	1,350	19	45
	August	1,320	16	40
	September	1,330	NA	33
Lansing	July	1,340	14	39
	August	1,350	12	35
	September	1,330	NA	26
Marquette	July	1,330	29	102
	August	1,310	23	77
	September	1,290	NA	66
Monroe	July	1,380	12	23
	August	1,360	10	22
	September	1,290	NA	19
Saginaw	July	1,330	12	35
	August	1,300	9	30
	September	1,340	NA	26
Average	July	1,340	18	48
	August	1,330	14	39
	September	1,320	NA	33

NA, no analysis.
[a] All iodine-131 values were below detection limit of 14 pCi/liter and barium-lanthanum-140 results reported as 0 for this period.

Figure 5. Michigan pasteurized milk network sampling locations

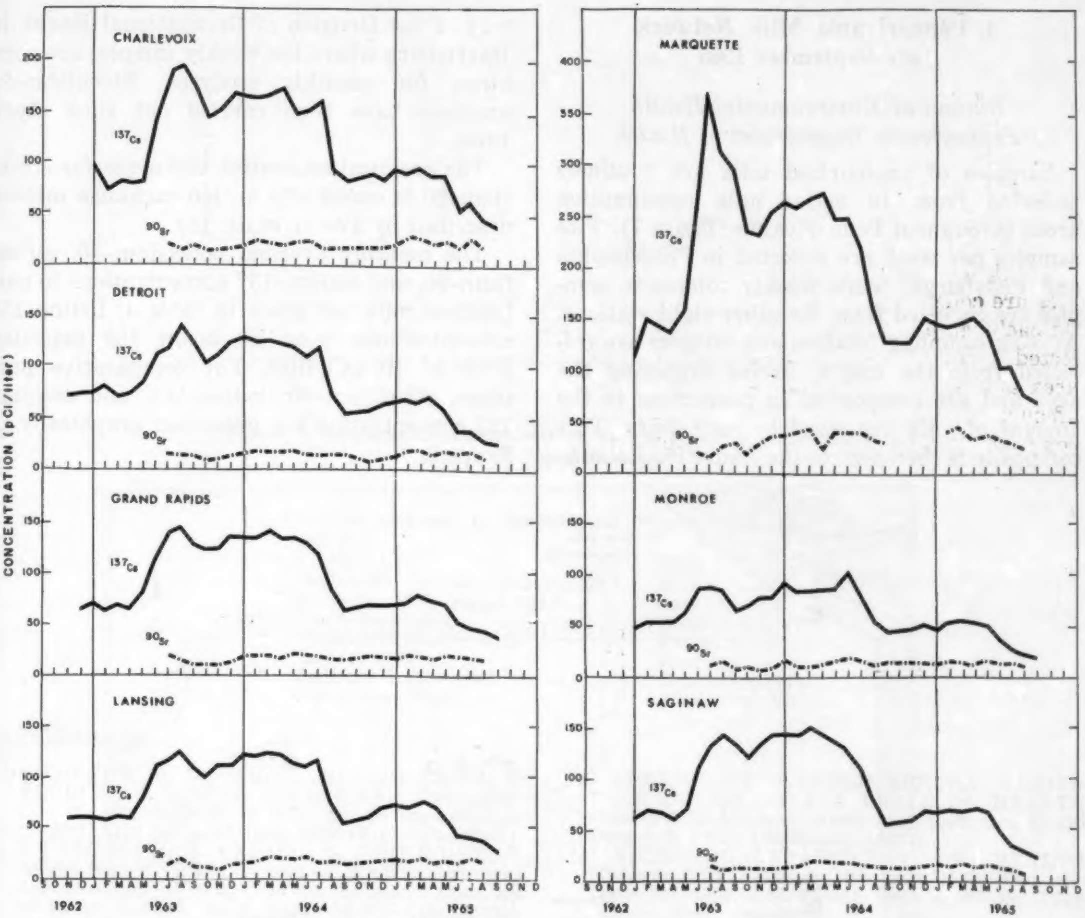

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962–September 1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
November 1962–December 1964	***September 1965***
Annual 1964	***September 1965***
January–June 1965	***November 1965***

4. Pennsylvania Milk Network July–September 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 7). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location sub-samples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter *et al.* (*2*).

The monthly average potassium–40, strontium–90, and cesium–137 concentrations in pasteurized milk are given in table 4. Iodine–131 concentrations were all below the detection limit of 10 pCi/liter. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentration are presented graphically in figure 8.

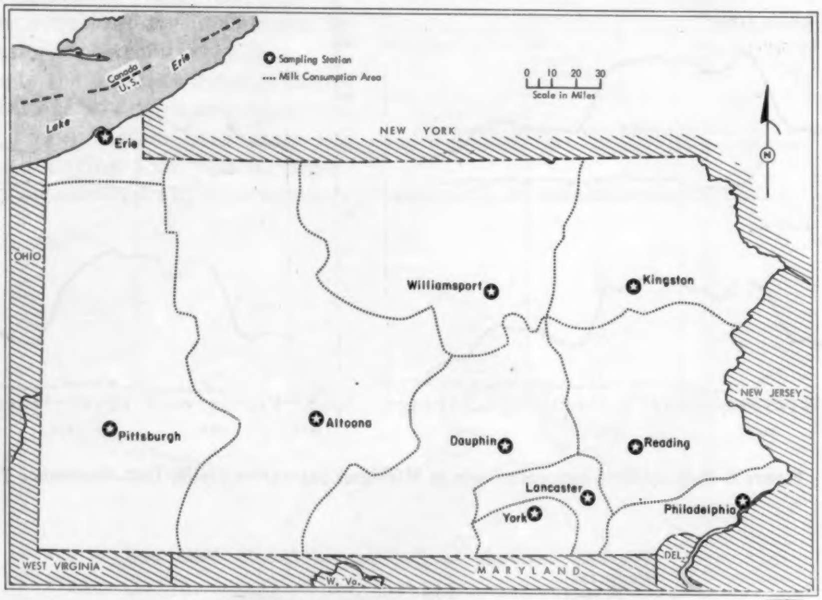

Figure 7. Pennsylvania pasteurized milk network sampling locations

Table 4. Potassium-40, strontium-90, and cesium-137 concentrations [a] in Pennsylvania milk, July–September 1965

Sampling locations	Radionuclide concentrations, pCi/liter								
	Potassium-40			Strontium-90			Cesium-137		
	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep
Altoona	1,010	1,040	990	13	14	14	72	59	55
Dauphin	990	1,050	980	9	8	12	73	72	53
Erie	1,060	1,000	1,130	16	13	18	102	91	72
Kingston	970	1,080	970	17	15	19	92	74	65
Lancaster	1,070	960	975	10	9	12	72	61	54
Philadelphia	1,080	1,060	1,015	11	11	15	74	66	57
Pittsburgh	970	1,030	980	19	15	18	88	77	61
Reading	1,025	1,020	980	10	15	12	76	68	56
Williamsport	1,050	1,030	1,025	12	12	12	101	75	68
York	1,000	1,050	1,110	11	13	13	70	63	66
Average	1,020	1,030	1,020	13	13	15	82	71	61

[a] All iodine-131 concentrations for this period were <10.

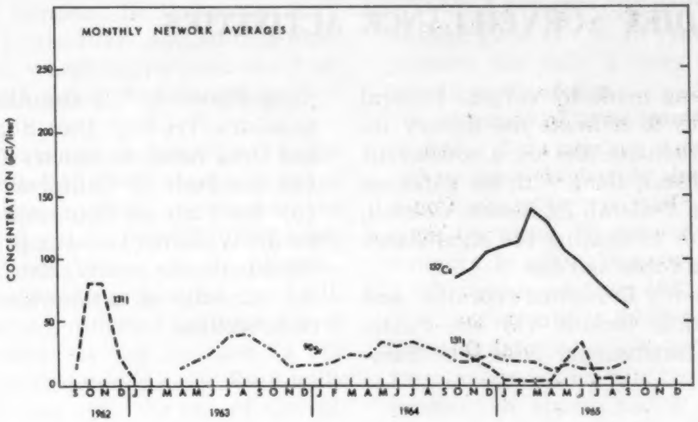

Figure 8. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962–September 1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*
Annual 1964	*June 1965*
January–March 1965	*September 1965*
April–June 1965	*November 1965*

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(*2*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(*3*) BUREAU OF ENVIRONMENTAL SANITATION, INDIANA STATE BOARD OF HEALTH. Indiana Milk Network, April–June 1965. Rad Health Data 6:612–614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan Milk Network, November 1962—December December 1964. Rad Health Data 6:487–492 (September 1965).

Other State coverage in *Radiological Health Data and Reports:*

Program	Period Reported	Last Presented
California Milk Network	April–June 1965	*December 1965*
Colorado Milk Network	October–December 1964	*April 1965*
Florida Milk Network	July–December 1964	*January 1966*
Minnesota Milk Network	July–December 1964	*January 1966*
Oklahoma Milk Network	March–July 1965	*October 1965*
Oregon Milk Network	January–March 1965	*August 1965*
New York Milk Network	January–March 1965	*January 1966*
Texas Milk Network	January–March 1965	*October 1965*
Washington Milk Network	January–March 1965	*November 1965*

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides.

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, APRIL-JUNE 1965

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is conducted by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially the program consisted of sampling at eight institutions; as of January 1965, sampling had increased to boarding schools or institutions in 50 municipalities, distributed as shown in figure 1. These institutions range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of those at Los Angeles, California; Fargo, North Dakota; Columbia, Mississippi; Carson City, Nevada; and Sioux Falls, South Dakota) is located in a community from which the PHS Pasteurized Milk Network

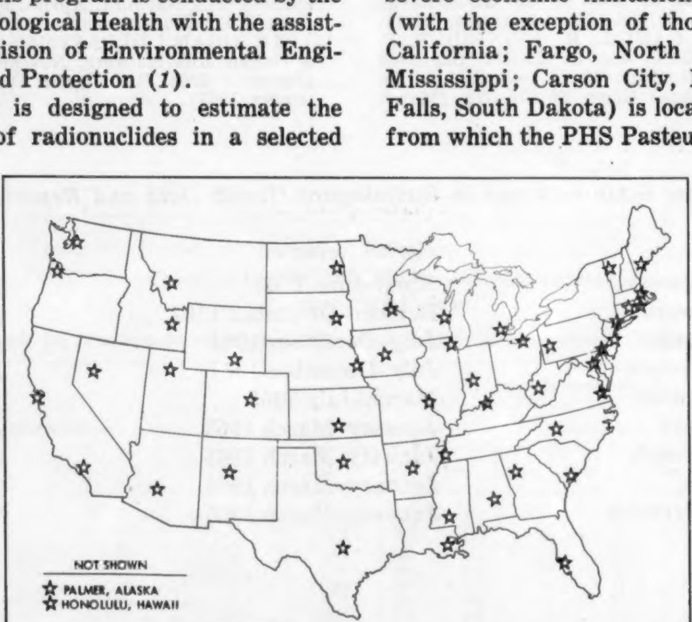

Figure 1. Institutional diet sampling locations

(PMN) collects samples. In those communities not sampled by the PMN, special milk samples are collected which supplement the findings for the Institutional Diet Sampling Program.

In general, the sampling procedure is the same at each institution. Each sample supplied by each institution monthly represents the edible portion of the diet for a full 7-day week (21 meals, plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water is not included in the samples but is sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*2*).

Results

Table 1 gives the analytical results for institutional diet samples collected from April through June 1965. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. A maximum of 51 institutions in 50 municipalities participated in this sampling program during this period.

When discussing intake on a per-day basis, it is meaningful to delineate differences resulting from age and sex. In an effort to evaluate these differences, table 2 presents the dietary intake of teenage boys (13 to 18 years of age) on a per-day basis. The intake values were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine-131 and barium-140 were interpreted as zero and "less than" 5 pCi/kg of strontium-89 as 2.5 pCi/kg.

Table 3 presents the daily dietary intake of teenage girls (13 to 18 years of age). Table 4 presents the daily dietary intake of children 9 to 12 years of age.

A summary of these results (table 5) shows a variation between age groups. Teenage girls and younger children have comparable intakes, while teenage boys consistently have higher intakes by about 20 percent. These values are comparable with the network average of 1.90 kg/day observed from 1961 to 1964 (*3*).

Where strontium-89 dietary intake remained below detectable levels, the strontium-90 dietary intake during this period remained fairly constant at approximately 27 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*4*). While the Radiation Protection Guides (RPG's) and related intake ranges were developed for controlling normal peacetime operations, nevertheless, annual radiation doses from fallout equal to or greater than the RPG's can be used to indicate a need to initiate an evaluation of fallout exposures. The current strontium-90 levels indicate that surveillance must be adequate to provide estimates of the probable variations in average daily intake in time and location.

Cesium-137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*3*). During this period, both barium-140 and iodine-131 concentrations were below detectable levels.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July-September 1963	*March 1964*
October-December 1963	*July 1964*
January-March 1964	*October 1964*
April-June 1964	*January 1965*
July-September 1964	*April 1965*
October-December 1964	*July 1965*
1964 Annual Averages	*July 1965*
January-March 1965	*October 1965*

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(*2*) DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Radionuclides in institutional total diet samples, January-March 1965. Rad Health Data 6:548-554 (October 1965).

(*3*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961-1964. Rad Health Data 6:691-698 (December 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

Table 1. Institutional diet analytical results, all schools, second quarter 1965

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery	Apr	0.6	1.6	<5	12	25	NA
		May	0.6	1.1	<5	14	50	NA
		June	0.5	1.0	<5	10	25	NA
Alaska:	Palmer	Apr	0.6	1.2	<5	15	70	0.3
		May	0.6	1.2	<5	27	60	0.5
		June	0.8	1.6	<5	21	70	0.5
Ariz:	Phoenix	Apr	0.7	1.4	<5	18	45	0.5
		May	0.8	1.7	<5	19	60	0.5
		June	0.7	1.3	<5	11	30	0.6
Ark:	Little Rock	Apr	0.8	1.0	<5	28	40	NA
		May	0.7	1.5	<5	24	45	NA
		June	0.6	1.2	<5	19	30	NA
Calif:	Los Angeles	Apr	0.8	1.0	<5	5	25	0.8
		May	0.6	1.3	<5	7	30	0.5
		June	0.6	1.5	<5	7	30	0.4
	San Francisco [a]	Apr	0.6	1.4	<5	11	30	0.3
		May	0.7	1.4	<5	18	35	0.5
		June	6.6	2.0	<5	9	40	0.8
Colo:	Denver	Apr	0.8	1.6	<5	17	85	0.7
		May	0.6	1.3	<5	12	35	0.7
		June	0.7	1.5	<5	17	65	0.6
Conn:	Hartford	Apr	0.7	1.6	<5	9	80	0.7
		May	0.7	1.8	<5	11	80	0.5
		June	0.8	1.5	5	12	50	0.6
Del:	Wilmington	Apr	0.8	1.6	<5	12	55	0.8
		May	0.8	1.6	<5	12	55	0.7
		June	0.8	1.6	<5	14	55	0.8
Fla:	Tampa	Apr	0.7	1.5	<5	16	100	NA
		May	0.6	2.0	<5	11	105	NA
		June	0.9	1.5	<5	12	110	NA
Ga:	Atlanta	Apr	0.6	1.4	<5	18	75	NA
		May	0.5	1.6	<5	19	50	NA
		June	0.6	1.5	<5	18	45	NA
Hawaii:	Honolulu	Apr	0.5	1.1	<5	12	35	1.0
		May	0.7	1.2	<5	14	35	1.2
		June	0.6	1.2	<5	23	25	0.7
Idaho:	Idaho Falls	Apr	0.7	1.6	<5	27	120	0.5
		May	0.7	1.6	<5	29	85	0.6
		June	0.6	1.5	<5	20	55	0.6
Ill:	Chicago	Apr	0.7	1.4	<5	9	70	0.5
		May	0.8	1.7	<5	13	75	0.7
		June	0.6	1.6	<5	11	60	0.5
Ind:	Indianapolis	Apr	0.9	1.4	<5	14	65	0.8
		May	0.8	1.4	5	13	55	0.4
		June	0.8	1.5	15	12	40	0.8
Iowa:	Des Moines	Apr	0.7	1.6	<5	17	60	NA
		May	0.7	1.6	<5	15	70	NA
		June	0.4	1.1	<5	12	30	NA
Kans:	Wichita	Apr	0.8	1.6	<5	19	50	NA
		May	0.7	1.4	<5	12	40	NA
		June	0.8	1.6	<5	12	40	NA
Ky:	Louisville	Apr	0.5	1.1	<5	18	35	NA
		May	0.5	0.9	<5	13	25	NA
		June	0.6	1.3	<5	16	30	NA
La:	New Orleans	Apr	0.6	1.6	<5	19	55	NA
		May	0.6	1.3	<5	18	50	NA
		June	0.6	1.2	<5	19	40	NA
Maine:	Portland	Apr	0.8	1.5	<5	12	85	0.5
		May	0.8	1.4	<5	15	95	0.8
		June	0.8	1.4	<5	17	70	0.6
Md:	Baltimore	Apr	0.6	1.6	<5	14	45	NA
		May	0.7	1.5	<5	17	60	NA
		June	0.7	1.4	<5	18	50	NA
Mass:	Boston A [b]	Apr	0.6	1.5	<5	11	65	0.8
		May	0.6	1.4	5	9	95	0.4
		June	0.7	1.3	5	14	65	0.5
	Boston B [b]	Apr	0.5	1.3	<5	9	50	0.6
		May	0.6	1.4	<5	7	40	0.5
		June	0.5	1.2	<5	6	45	0.4
Mich:	Detroit	Apr	0.9	1.6	<5	12	75	0.9
		May	0.7	1.3	<5	8	70	0.7
		June	0.7	1.6	<5	7	55	0.8
Minn:	Minneapolis	Apr	0.9	1.8	<5	17	45	1.1
		May	0.7	1.6	<5	24	80	0.6
		June	0.6	1.4	<5	19	60	0.7
Miss:	Columbia	Apr	0.8	1.4	<5	23	75	NA
		May	0.8	1.4	<5	22	70	NA
		June	0.8	1.6	<5	18	60	NA
Mo:	St. Louis	Apr	0.8	1.0	<5	15	30	0.8
		May	0.7	1.7	<5	25	30	1.2
		June	0.7	1.5	<5	16	25	0.7

Table 1. Institutional diet analytical results, all schools, first quarter 1965—Continued

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Mont:	Helena	Apr	0.5	1.4	<5	12	60	1.2
		May	0.4	1.3	<5	13	45	0.6
		June	0.4	0.9	<5	7	30	0.4
Nebr:	Omaha	Apr	0.9	1.6	<5	22	75	0.9
		May	0.7	1.3	<5	20	55	0.7
		June	0.7	1.5	<5	16	60	0.5
Nev:	Carson City	Apr	0.8	1.4	<5	9	55	0.5
		May	0.7	1.1	<5	7	35	0.6
		June	0.8	1.5	<5	11	45	0.3
N. J:	Trenton	Apr	0.5	1.4	<5	10	65	0.7
		May	0.8	1.4	<5	13	45	0.5
		June	0.8	1.1	<5	18	50	1.4
N. Mex:	Albuquerque	Apr	0.8	1.3	<5	10	30	0.7
		May	0.8	1.6	<5	13	45	0.7
		June	0.8	1.6	<5	14	25	0.5
N. Y:	New York	Apr	1.0	1.6	<5	12	75	0.7
		May	0.7	1.4	<5	18	70	1.0
		June	NS	NS	NS	NS	NS	NS
N. C:	Charlotte	Apr	0.6	1.2	<5	13	50	NA
		May	0.6	0.9	<5	17	50	NA
		June	0.6	1.1	<5	14	20	NA
N. Dak:	Fargo	Apr	0.8	1.6	<5	13	80	0.4
		May	0.6	1.3	<5	15	65	0.3
		June	0.7	1.4	10	16	60	0.7
Ohio:	Cleveland	Apr	0.6	1.7	<5	15	65	0.5
		May	0.7	1.7	<5	10	55	0.7
		June	0.7	1.7	10	11	75	0.7
Okla:	Oklahoma City	Apr	0.6	1.4	<5	12	30	NA
		May	0.7	1.5	<5	12	35	NA
		June	0.5	1.1	<5	10	20	NA
Ore:	Portland	Apr	0.6	1.7	<5	9	60	NA
		May	0.6	1.5	<5	17	60	0.6
		June	0.5	1.4	<5	14	55	0.5
Pa:	Pittsburgh	Apr	0.6	1.5	<5	14	70	0.6
		May	0.4	1.3	<5	13	60	0.4
		June	0.6	1.3	5	16	60	1.1
R. I:	Providence	Apr	0.8	1.5	<5	12	85	0.3
		May	0.8	1.6	<5	8	80	9.6
		June	0.8	1.5	5	13	60	0.6
S. C:	Charleston	Apr	0.7	1.4	<5	10	65	NA
		May	0.8	1.5	<5	21	75	NA
		June	0.6	1.1	<5	14	50	NA
S. Dak:	Sioux Falls	Apr	0.7	1.6	15	8	70	0.4
		May	0.8	1.6	<5	15	70	0.9
		June	0.8	1.7	5	22	75	0.7
Tenn:	Memphis	Apr	0.7	1.6	<5	22	45	NA
		May	0.6	1.4	<5	17	35	NA
		June	0.6	1.4	<5	16	40	NA
Tex:	Austin	Apr	0.4	1.0	<5	8	25	NA
		May	0.4	1.3	<5	8	20	NA
		June	0.4	1.0	<5	6	30	NA
Utah:	Salt Lake City	Apr	0.6	1.6	<5	13	75	0.5
		May	0.7	1.4	<5	18	45	0.8
		June	0.5	1.5	<5	15	75	0.4
Vt:	Burlington	Apr	0.7	1.7	<5	14	95	0.7
		May	1.0	1.6	<5	16	100	0.3
		June	1.0	1.5	<5	16	60	0.9
Va:	Norfolk	Apr	0.5	1.2	<5	14	55	NA
		May	0.5	1.4	<5	21	45	NA
		June	0.5	1.0	<5	14	35	NA
Wash:	Seattle	Apr	0.8	1.6	<5	19	65	0.2
		May	0.7	1.5	<5	34	75	0.5
		June	0.5	1.5	<5	18	70	0.4
W. Va:	Charleston	Apr	0.8	1.4	<5	23	60	NA
		May	0.8	1.5	<5	19	45	NA
		June	0.7	1.6	<5	18	45	NA
Wis:	Milwaukee	Apr	0.6	1.5	<5	11	75	0.6
		May	0.6	1.6	<5	10	70	0.9
		June	0.7	1.7	5	11	55	0.8
Wyo:	Laramie	Apr	0.7	1.5	<5	13	65	0.5
		May	0.7	1.7	<5	18	50	1.2
		June	0.5	1.6	<5	19	75	0.9
Institution average		Apr	0.7	1.5	<5	14	60	0.6
		May	0.7	1.4	<5	16	55	0.7
		June	0.7	1.4	<5	14	50	0.6

[a] Institution became part of network in April 1965.
[b] "A" and "B" denote two separate institutions in Boston.
NA, no analysis.
NS, no samples

Table 2. Institutional diet daily intakes, teenage boys, second quarter 1965

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery	15–17	Apr	2.17	1.3	3.5	5	26	55	NA
		15–17	May	2.25	1.4	2.5	5	32	110	NA
		15–17	June	2.15	1.1	2.2	5	22	55	NA
Hawaii:	Honolulu	14–17	Apr	1.91	1.0	2.1	5	23	65	1.9
		15–17	May	1.90	1.3	2.3	5	27	65	2.3
		14–17	June	1.97	1.2	2.4	5	45	50	1.4
Idaho:	Idaho Falls	17	Apr	1.82	1.3	2.9	5	49	220	0.9
		17	May	1.94	1.4	3.1	5	56	165	1.2
		17	June	1.91	1.1	2.9	5	38	105	1.1
Iowa:	Des Moines	13–16	Apr	2.59	1.8	4.1	5	44	155	NA
		14–15	May	3.19	2.2	5.1	10	48	225	NA
		13–16	June	1.89	0.8	2.1	5	23	55	NA
Ky:	Louisville	15–16	Apr	1.80	0.9	2.0	5	32	65	NA
		15–16	May	1.99	1.0	1.8	5	26	50	NA
		15–17	June	1.61	1.0	2.1	5	21	50	NA
Maine:	Portland	14	Apr	2.34	1.9	3.5	5	28	200	1.2
		14	May	2.36	1.9	3.3	5	35	225	1.9
		14	June	2.25	1.8	3.2	5	38	160	1.4
Minn:	Minneapolis	13–16	Apr	2.18	2.0	3.9	5	37	100	2.4
		14–15	May	1.86	1.3	3.0	5	45	150	1.1
		15–17	June	2.05	1.2	2.9	5	39	125	1.4
Miss:	Columbia	15–17	Apr	2.29	1.8	3.2	5	53	170	NA
		15–17	May	2.38	1.9	3.3	5	52	165	NA
		15–17	June	1.99	1.6	3.2	5	36	120	NA
Mo:	St. Louis	15–17	Apr	2.79	2.2	2.8	5	42	85	2.2
		15–17	May	2.50	1.8	4.2	5	62	75	3.0
		15–17	June	2.19	1.5	3.3	5	35	55	1.5
Nebr:	Omaha	16–18	Apr	1.94	1.7	3.1	5	43	145	1.7
		15–17	May	1.84	1.3	2.4	5	35	100	1.3
		15–16	June	1.91	1.4	2.9	5	31	120	1.0
N. J:	Trenton	15–17	Apr	2.35	1.2	3.3	5	24	155	1.6
		14–17	May	2.47	2.0	3.5	5	32	110	1.2
		16–17	June	1.71	1.4	1.9	5	31	85	2.4
Ore:	Portland	15–17	Apr	2.40	1.4	4.1	5	22	145	NA
		15–17	May	2.30	1.4	3.4	5	39	140	1.4
		12–17	June	2.44	1.2	3.4	5	34	135	1.2
Pa:	Pittsburgh	14–17	Apr	2.40	1.4	3.6	5	34	170	1.4
		14–17	May	2.35	0.9	3.1	5	31	140	0.9
		14–16	June	2.37	1.4	3.1	10	38	140	2.6
R. I:	Providence	13–15	Apr	2.71	2.2	4.1	5	33	230	0.8
		13–15	May	2.74	2.2	4.4	5	22	220	1.6
		13–15	June	2.31	1.8	3.5	10	30	140	1.4
Tex:	Austin	15–18	Apr	1.92	0.8	1.9	5	15	50	NA
		15–17	May	1.94	0.8	2.5	5	16	40	NA
		15–17	June	1.99	0.8	2.0	5	12	60	NA
Va:	Norfolk	15–17	Apr	2.34	1.2	2.8	5	33	130	NA
		15–17	May	2.31	1.2	3.2	5	49	105	NA
		15–17	June	2.29	1.1	2.3	5	32	80	NA
Wis:	Milwaukee	15–16	Apr	2.14	1.3	3.2	5	24	160	1.3
		15–18	May	2.06	1.2	3.3	5	21	145	1.9
		15–18	June	1.90	1.3	3.2	10	21	105	1.5

NA, no analysis.

Table 3. Institutional diet daily intakes, teenage girls, second quarter 1965

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Calif:	San Francisco	15	Apr	1.98	1.2	2.8	5	22	60	0.6
		15	May	1.52	1.1	2.1	5	27	55	0.8
		15	June	1.59	1.0	3.2	5	14	65	1.3
Conn:	Hartford	13–20	Apr	1.80	1.3	2.9	5	16	145	1.3
		15	May	1.79	1.3	3.2	5	20	145	0.9
		14–16	June	1.84	1.5	2.8	10	22	90	1.1
Ga:	Atlanta	9–11	Apr [a]	1.64	1.0	2.3	5	30	125	NA
		9–12	May [a]	1.79	0.9	2.9	5	34	90	NA
		12–11	June [b]	1.65	1.0	2.5	5	30	75	NA
La:	New Orleans	15–17	Apr	2.63	1.6	4.2	5	50	145	NA
		13–17	May	2.56	1.5	3.3	5	45	130	NA
		13–17	June	2.34	1.4	2.8	5	44	95	NA

Table 3. Institutional diet daily intakes, teenage girls, second quarter 1965—Continued

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium89-	Strontium-90	Cesium-137	Radium-226
Mont:	Helena	15–17	Apr	1.38	0.7	1.9	5	17	85	1.7
		16–18	May	1.16	0.5	1.5	5	15	50	0.7
		13–16	June	1.17	0.5	1.1	5	8	35	0.5
N. Y:	New York	10–12	Apr [a]	2.24	2.2	3.6	5	27	170	1.6
		10–12	May [a]	2.39	1.7	3.3	5	43	165	2.4
		NS	June	NS	NS	NS	NS	NS	NS	NS
N. C:	Charlotte	15–17	Apr	1.16	0.7	1.4	5	15	60	NA
		15–17	May	1.55	0.9	1.4	5	26	80	NA
		15–17	June	1.37	0.8	1.5	5	19	25	NA
Tenn:	Memphis	15–18	Apr	1.68	1.2	2.7	5	37	75	NA
		15–17	May	1.69	1.0	2.4	5	29	60	NA
		15–19	June	1.83	1.1	2.6	5	29	75	NA
Utah:	Salt Lake City	16–17	Apr	1.18	0.7	1.9	5	15	90	0.6
		16–17	May	1.10	0.8	1.5	5	20	50	0.9
		15–17	June	1.56	0.8	2.3	5	23	115	0.6
Wash:	Seattle	15–17	Apr	2.04	1.6	3.3	5	39	135	0.4
		15–18	May	2.04	1.4	3.1	5	69	155	1.0
		15–17	June	1.84	0.9	2.8	5	33	130	0.7

[a] Data for these months were not used in the average because food samples were collected from boys as well as girls.
[b] Data for this month were not used in average because food samples were collected from two or more children who were less than 13 years of age.
NS, no sample.
NA, no analysis.

Table 4. Institutional diet daily intakes, children (9–12 years), second quarter 1965

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	10–12	Apr	1.67	1.0	2.0	5	25	115	0.5
		10–12	May	1.56	0.9	1.9	5	42	95	0.8
		10–12	June	1.56	1.2	2.5	5	33	110	0.8
Ariz:	Phoenix	12–13	Apr [a]	1.60	1.1	2.2	5	29	70	0.8
		12–13	May [a]	1.77	1.4	2.0	5	34	105	0.9
		9–12	June	1.90	1.3	2.5	5	21	55	1.1
Ark:	Little Rock	11–12	Apr	1.96	1.6	2.0	5	55	80	NA
		10–12	May	1.86	1.3	2.8	5	45	85	NA
		10–12	June	1.99	1.2	2.4	5	38	60	NA
Calif:	Los Angeles	10–13	Apr	1.68	1.3	2.7	5	8	40	1.3
		11–13	May [a]	1.96	1.2	2.5	5	14	60	1.0
		11–14	June [a]	1.64	1.0	2.5	5	11	50	0.7
Colo:	Denver	11–13	Apr	2.48	2.0	4.0	5	42	210	1.7
		10–15	May [a]	2.42	1.5	3.1	5	29	85	1.7
		10–12	June	1.88	1.3	2.8	5	32	120	1.1
Del:	Wilmington	10–12	Apr	1.85	1.5	3.0	5	22	100	1.5
		10–12	May	1.78	1.4	2.8	5	21	100	1.2
		10–12	June	1.72	1.4	2.8	5	24	95	1.4
Fla:	Tampa	10–11	Apr	2.12	1.5	3.2	5	34	210	NA
		10–12	May	2.06	1.2	4.1	5	23	215	NA
		10–12	June	2.25	2.0	3.4	5	27	250	NA
Ill:	Chicago	11–12	Apr	1.30	10.8	1.8	5	12	90	0.6
		11–12	May	1.56	1.2	2.7	5	20	120	1.1
		11–12	June	1.21	0.7	1.9	5	13	75	0.6
Ind:	Indianapolis	11–12	Apr	1.56	1.4	2.2	5	22	100	1.2
		10–12	May	1.54	1.2	2.2	10	20	85	0.6
		10–12	June	1.54	1.2	2.3	25	18	60	1.2
Kans:	Wichita	10–12	Apr	1.85	1.5	3.0	5	35	90	NA
		11–16	May [a]	1.93	1.4	2.7	5	23	75	NA
		10–12	June	1.98	1.6	3.2	5	24	80	NA
Md:	Baltimore	10–12	Apr	1.64	1.0	2.6	5	23	75	NA
		10–12	May	1.78	1.2	2.7	5	30	105	NA
		10–12	June	1.88	1.3	2.6	5	34	95	NA
Mass:	Boston A	10–12	Apr	2.65	1.6	4.0	5	29	170	2.1
		10–12	May	2.42	1.5	3.4	10	22	230	1.0
		11–12	June	2.29	1.6	3.0	10	32	150	1.1
	Boston B	10–12	Apr	2.27	1.1	3.0	5	20	115	1.4
		10–12	May	2.17	1.3	3.0	5	15	85	1.1
		10–12	June	2.53	1.3	3.0	5	15	115	1.0

Table 4. Institutional diet daily intakes, children (9–12 years), second quarter 1965—Continued

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Mich:	Detroit	11–12	Apr	2.09	1.9	3.3	5	25	155	1.9
		11–12	May	1.84	1.3	2.4	5	15	130	1.3
		10–12	June	1.83	1.3	2.9	5	13	100	1.5
Nev:	Carson City	10–12	Apr	1.50	1.2	2.1	5	14	80	0.8
		10–12	May	1.28	0.9	1.4	5	9	45	0.8
		10–12	June	1.90	1.5	2.8	5	21	85	0.6
N. Mex:	Albuquerque	10–12	Apr	2.16	1.7	2.8	5	22	65	1.5
		10–12	May	2.13	1.7	3.4	5	28	95	1.5
		10–12	June	1.99	1.6	3.2	5	28	50	1.0
N. Dak:	Fargo	10–12	Apr	1.58	1.3	2.5	5	20	125	0.6
		9–12	May	1.56	0.9	2.0	5	23	100	0.5
		10–12	June	1.09	0.8	1.5	10	17	65	0.8
Ohio:	Cleveland	10–11	Apr	1.45	0.9	2.5	5	22	95	0.7
		11–12	May	1.30	0.9	2.2	5	13	70	0.9
		10–11	June	1.45	1.0	2.5	15	16	110	1.0
Okla:	Oklahoma City	11–14	Apr [a]	1.76	1.1	2.5	5	21	55	NA
		10–12	May	1.69	1.2	2.5	5	20	60	NA
		10–12	June	1.91	1.0	2.1	5	19	40	NA
S. C:	Charleston	11–12	Apr	2.15	1.5	3.0	5	41	140	NA
		11–12	May	1.35	1.1	2.0	5	28	100	NA
		10–12	June	1.80	1.1	2.1	5	26	95	NA
S. Dak:	Sioux Falls	11	Apr	1.91	1.3	3.1	30	15	135	0.8
		11–12	May	1.74	1.4	2.8	5	26	120	1.6
		10–11	June	1.76	1.4	3.0	10	39	130	1.2
Vt:	Burlington	10–12	Apr	1.37	1.0	2.3	5	19	130	1.0
		10–12	May	1.42	1.4	2.3	5	23	140	0.4
		10–12	June	1.32	1.3	2.0	5	21	80	1.2
W. Va:	Charleston	10–12	Apr	1.61	1.3	2.3	5	37	95	NA
		10–12	May	1.55	1.2	2.3	5	29	70	NA
		10–11	June	1.57	1.1	2.5	5	28	70	NA
Wyo:	Laramie	11	Apr	1.89	1.3	2.8	5	25	125	0.9
		11	May	1.50	1.1	2.7	5	29	80	1.9
		11	June	1.58	0.8	2.5	5	30	120	1.4

[a] Data for these months were not used in average because food samples were collected from two or more children who were over 12 years of age.
NA, no analysis.

Table 5. Summary of ITDSN intake for April through June 1965 [a]

Sampling groups	Month 1965	Number of institutions	Intakes						
			Weight (kg/day)	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
				(grams/day)		(picocuries/day)			
Teenage boys	April	17	2.24	1.5	3.2	5	33	135	1.5
	May	17	2.26	1.5	3.2	5	37	130	1.6
	June	17	2.06	1.3	2.7	5	31	95	1.5
Teenage girls	April	8	1.73	1.0	2.6	5	26	100	0.9
	May	8	1.68	1.1	2.3	5	31	90	0.9
	June	9	1.69	1.0	2.4	5	24	80	0.8
Children	April	22	1.85	1.4	2.7	5	26	115	1.2
	May	20	1.71	1.2	2.6	5	24	105	1.0
	June	23	1.78	1.3	2.6	5	25	95	1.1

[a] Iodine -131 and barium-140 values all 0 for this period.

ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CONNECTICUT STANDARD DIET, JANUARY-JUNE 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. These analyses included strontium-89, strontium-90, and gamma-emitting radionuclides.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices	Ice cream—½ pint
Butter, ½ stick	Lettuce, washed—4-5 leaves
Carrots, scraped—½ cup	Milk—3 cups
Celery, washed and trimmed—3 stalks	Oatmeal, uncooked—43 grams
Cookies—4	Orange—1
Cottage cheese—⅔ cup	Peanut butter—2½ tablespoons
Cupcakes—2	Pears, canned—2 halves with juice
Egg—1	Potatoes, washed, not peeled—2
Green beans, washed—½ cup	Sugar—5 tablespoons
Ham—85 grams	Tomato juice—113 grams
Hamburger—227 grams	Tuna fish, drained—43 grams

Cesium-137 radionuclide concentrations were determined by gamma-scintillation spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from January through June 1965.

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] January-June 1965

Month (1965)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January	2.3	12.9	70
February	2.3	11.0	60
March	2.2	15.4	80
April	2.2	14.4	70
May	2.0	18.5	120
June	2.2	14.6	70

[a] All strontium-89 values <3 for this period.

Results representative of the total daily intake for the radionuclides observed are presented in table 3.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] January-June 1965

Month (1965)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	7.3	41.2	230
February	7.0	34.4	190
March	6.9	48.4	250
April	7.4	49.7	240
May	6.4	59.9	390
June	6.5	44.0	210

[a] All strontium-89 values <3 for this period.

In order to evaluate general trends, the strontium-90 and cesium-137 daily intakes are plotted as a function of time in figure 1.

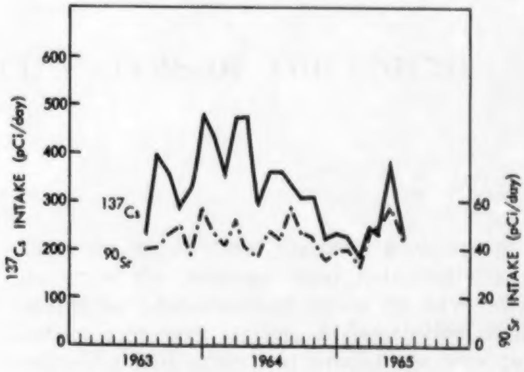

Figure 1. Radionuclide intake in Connecticut standard diet

REFERENCE

(*1*) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963—December 1964. Rad Health Data 6:381-382 (July 1965).

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
March 1963-December 1964	*July 1965*

Previous coverage in *Radiological Health Data and Reports*:

Activity	Period reported	Last presented
Institutional Total Diet	January–March 1965	*October 1965*
Tri-City Diet	February–April 1965	*December 1965*
Teenage Diet	February–November 1964	*July 1965*
California Diet	November–December 1964	*December 1965*
Connecticut Standard Diet	March 1963–December 1964	*July 1965*

Section II. Water

The Public Health Service (and as of January 1966, the Federal Water Pollution Control Administration) and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the values secured with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively, without considering other sources of radioactivity. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity.[1] Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, AUGUST 1965

Basic Data Branch
Federal Water Pollution Control Administration[2]

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the newly created Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 geographically presents the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the December 1965 issue of *RHD* (*5*).

Complete data and exact sampling locations are published in annual compilations (*6–11*) or are available on request.

Comments on data are being made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. Changes toward or from these levels are discussed in terms of significant changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System

[2] Data collected for this reporting period by the Division of Water Supply and Pollution Control.

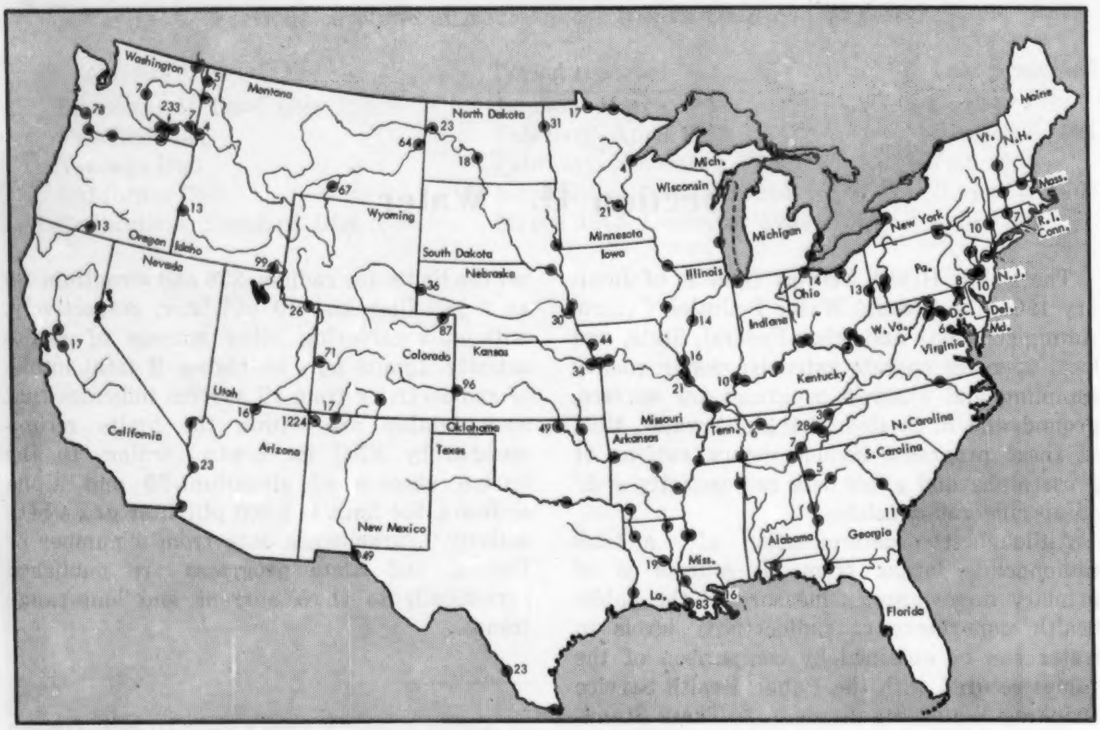

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, August 1965

will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha values on suspended and/or dissolved solids of 15 pCi/liter or more for both July and August: South Platte River, Julesburg, Colorado and Yellowstone River, Sidney, Montana. These stations showed reasonable values for alpha radioactivity per gram of suspended and/or dissolved solids. The following stations showed a decline to an alpha radioactivity of less than 15 pCi/liter from the month of July: Kansas River, DeSoto, Kansas; Missouri River, St. Joseph, Missouri; and Platte River, Plattsmouth, Nebraska. The following stations showed increases of alpha radioactivity from less than 15 pCi/liter in July to more than this value for August 1965; Arkansas River, Coolidge, Kansas; North Platte River, Henry, Nebraska; Atchafalaya River, Morgan City, Louisiana; Missouri River, Bismarck, North Dakota; San Juan River, Shiprock, New Mexico; Colorado River, Loma, Colorado; and an increase in dissolved solids beta activity of sample from the Columbia River at Pasco, Washington. At Morgan City, the high level of suspended solids is responsible for the high activities observed. Coolidge, Kansas, shows high suspended and dissolved solids while Henry, Nebraska, shows high dissolved solids with a characteristic alpha activity per gram. Shiprock is interesting in that the first sample of three collected during the month had suspended solid levels in excess of 50,000 mg/liter. This, in turn, produced high alpha and high beta activities for both suspended and dissolved solids, even though the latter two samples showed usual low activities and normal solids concentration. Pasco showed increased beta activity on dissolved solids. The period of high river flow is now past and concentrations of dissolved solids are again at higher levels.

Table 1. Radioactivity in raw surface waters, August 1965
(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	11	6	17	4	1	5
Arkansas River:						
Coolidge, Kans	70	26	96	27	7	34
Ponca City, Okla	24	25	49	5	10	15
Atchafalaya River:						
Morgan City, La	69	14	83	29	2	31
Bear River:						
Preston, Idaho	11	88	99	3	2	5
Big Horn River:						
Hardin, Mont	45	22	67	9	7	16
Chena River:						
Fairbanks, Alaska	0	3	3	0	<1	<1
Clearwater River:						
Lewiston, Idaho	1	3	4	<1	0	<1
Clinch River:						
Clinton, Tenn	0	3	3	0	0	0
Kingston, Tenn	4	24	28	<1	0	<1
Colorado River:						
Loma, Colo	55	16	71	19	8	27
Page, Ariz	1	15	16	0	3	3
Parker Dam, Calif-Ariz	1	22	23	0	12	12
Columbia River:						
Wenatchee, Wash	1	6	7	0	1	1
Pasco. Wash	47	186	233	0	1	1
Clatskanie, Ore	13	65	78	0	<1	<1
Connecticut River:						
Enfield Dam, Conn	1	6	7	0	0	0
Coosa River:						
Rome, Ga	1	4	5	<1	<1	<1
Cumberland River:						
Cheatham Lock, Tenn	1	5	6	0	0	0
Delaware River:						
Philadelphia, Pa	2	8	10	0	0	0
Great Lakes:						
Duluth, Minn	1	3	4	0	0	0
Green River:						
Dutch John, Utah	1	25	26	0	5	5
Hudson River:						
Poughkeepsie, N.Y	1	9	10	0	0	0
Illinois River:						
Peoria, Ill	1	13	14	0	2	2
Grafton, Ill	2	14	16	0	2	2
Kansas River:						
De Soto, Kans	12	22	34	4	2	6
Klamath River:						
Keno, Ore	<1	13	13	0	<1	<1
Maumee River:						
Toledo, Ohio	2	12	14	0	1	1
Mississippi River:						
St. Paul, Minn	1	20	21	0	1	1
E. St. Louis, Ill	3	18	21	1	2	3
New Orleans, La	4	12	16	1	1	2
Missouri River:						
Williston, N. Dak	4	19	23	1	7	8
Bismarck, N. Dak	1	17	18	<1	7	7
St. Joseph, Mo	24	20	44	10	5	15
North Platte River:						
Henry, Nebr	9	27	36	1	25	26
Ohio River:						
Toronto, Ohio	1	12	13	0	0	0
Cairo, Ill	1	8	9	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	5	5	0	1	1
Platte River:						
Plattsmouth, Nebr	8	22	30	2	4	6
Potomac River:						
Washington, D.C	0	6	6	0	0	0
Rainy River:						
Baudette, Minn	1	16	17	0	0	0
Red River, North:						
Grand Forks, N. Dak	4	27	31	1	2	3
Red River, South:						
Alexandria, La	2	17	19	0	2	2
Rio Grande:						
El Paso, Tex	32	17	49	13	3	16
Laredo, Tex	8	15	23	1	3	4
San Joaquin River:						
Vernalis, Calif	5	12	17	1	10	11
San Juan River:						
Shiprock, N. Mex	1,201	23	1,224	288	3	291
Savannah River:						
Port Wentworth, Ga	3	8	11	0	0	0
Snake River:						
Payette, Idaho	1	12	13	0	5	5
Wawawai, Wash	1	6	7	0	1	1
South Platte River:						
Julesburg, Colo	43	44	87	17	28	45
Susquehanna River:						
Conowingo, Md	0	8	8	0	0	0
Tennessee River:						
Chattanooga, Tenn	0	7	7	0	0	0
Wabash River:						
New Harmony, Ind	1	9	10	0	<1	<1
Yellowstone River:						
Sidney, Mont	53	11	64	17	4	21
Maximum	1,201	186	1,224	288	28	291
Minimum	0	3	3	0	0	0

NS, no sample.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Drinking Water Standards, revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963). Price 30 cents.

(2) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(5) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Gross radioactivity in surface waters of the United States, June 1965. Rad Health Data 6:707–710 (December 1965).

(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.50.

(7) *Ibid.*, 1959 Edition. Price $1.75.

(8) *Ibid.*, 1960 Edition.

(9) *Ibid.*, 1961 Edition.

(10) *Ibid.*, 1962 Edition.

(11) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES[3] JANUARY-JUNE 1965

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Crookston International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota

[3] Data and information from "Survey of Environmental Radioactivity, January-June 1965," Publication No. COO-651-17. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minnesota 55440.

Figure 1. Minnesota surface water sampling locations

Table 1. Total beta concentrations in Minnesota raw and treated water supplies, January–June 1965

(Monthly average concentrations in pCi/liter)

Town and water source	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	48	44	31	NS	20	51
	Treated	48	26	29	NS	30	36
East Grand Forks, Red Lake River	Raw	34	36	16	36	28	41
	Treated	13	16	12	23	13	23
Eveleth, St. Mary's Lake	Raw	30	19	17	23	20	24
	Treated	17	17	16	25	24	7
Fairmount, Budd Lake	Raw	24	13	20	13	20	26
	Treated	11	7	15	15	10	7
Hallock, Two Rivers South Fork	Raw	38	41	43	35	45	54
	Treated	10	13	7	11	14	12
International Falls, Rainy River	Raw	19	32	12	28	NS	13
	Treated	22	23	12	16	NS	7
Minneapolis tap water	Raw	NS	NS	NS	NS	NS	NS
	Treated	10	10	7	9	7	9
St. Cloud, Mississippi River	Raw	NS	15	7	22	NS	22
	Treated	NS	7	13	15	NS	7
St. Paul, Vadnais Chain of Lakes	Raw	18	13	12	23	18	32
	Treated	7	10	10	10	15	13

NS, no samples collected

municipal water supplies from January-June 1965. The minimum reported level corresponding to an error of one standard deviation is 15 pCi/liter at present. In averaging, the value 7 pCi/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 54 pCi/liter, which is well below the Public Health Service Drinking Water Standards of 1,000 pCi/liter (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

REFERENCE

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963). Price 30 cents.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
October 1957–August 1959	*April 1960*
August 1959–April 1962	*August 1962*
April 1962–November 1962	*April 1963*
December 1962–June 1963	*November 1963*
July–December 1963	*June 1964*
January–June 1964	*January 1965*
July–December 1964	*August 1965*

Other State coverage:

Program	Period covered	Last presented
California surface water sampling program	July–December 1964	*September 1965*
Florida water sampling program	1964	*November 1965*
Kentucky water sampling program	May 1963–June 1964	*March 1965*
New York surface water sampling program	June–December 1964	*September 1965*
North Carolina water sampling program	January–December 1964	*November 1965*
Washington surface water sampling program	July 1963–June 1964	*February 1965*

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercalibration of the above networks was performed by Lockhart (*1*) in 1962.

1. Radiation Surveillance Network October 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of daily field estimates

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, October 1965

Station location		Air surveillance: Number of samples: Air	Ppt	Gross beta activity, pCi/m³: Maximum	Minimum	Average	Last profile in *RHD & R*	Precipitation: Total depth (mm)	Total deposition (nCi/m²)[a]
Ala:	Montgomery	31	2	0.31	<0.10	<0.11	Feb 66	124	<25
Alaska:	Adak	30		<0.10	<0.10	<0.10	Sep 65	[c] —	
	Anchorage	20	4	<0.10	<0.10	<0.10	May 65	24	<5
	Attu Island	11		0.16	<0.10	<0.10	Oct 65	—	
	Fairbanks	(b)					Jun 65	—	
	Juneau	7	5	<0.10	<0.10	<0.10	Jul 65	59	<12
	Kodiak	2		<0.10	<0.10	<0.10	Aug 65	—	
	Nome	15		<0.10	<0.10	<0.10	Dec 65	—	
	Point Barrow	(b)					Nov 65	—	
	St. Paul Island	28		<0.10	<0.10	<0.10	Jan 66	—	
Ariz:	Phoenix	25		0.19	<0.10	<0.11	Jul 65	—	
Ark:	Little Rock	25	1	0.16	<0.10	<0.10	Jun 65	4	<1
Calif:	Berkeley	20	1	<0.10	<0.10	<0.10	Aug 65	6	<1
	Los Angeles	20		0.12	<0.10	<0.10	Dec 65	—	
C. Z:	Ancon	15		<0.10	<0.10	<0.10	Aug 65	—	
Colo:	Denver	30	2	0.16	<0.10	<0.10	Aug 65	15	<3
Conn:	Hartford	31	9	<0.10	<0.10	<0.10	Jul 65	88	<18
Del:	Dover	20		0.11	<0.10	<0.10	Feb 66	—	
D. C:	Washington	29	7	0.14	<0.10	<0.10	Nov 65	49	<10
Fla:	Jacksonville	31	8	0.15	<0.10	<0.10	Jun 65	46	<9
	Miami	27	10	0.14	<0.10	<0.10	Jul 65	158	<32
Ga:	Atlanta	(b)	1				Jan 66	11	<2
Guam:	Agana	30		0.14	<0.10	<0.10	Feb 66	—	
Hawaii:	Honolulu	30	4	<0.10	<0.10	<0.10	Oct 65	93	<19
Idaho:	Boise	27	1	0.12	<0.10	<0.10	Oct 65	9	<2
Ill:	Springfield	30		0.15	<0.10	<0.10	Nov 65	—	
Ind:	Indianapolis	28	9	0.11	<0.10	<0.10	Jan 66	35	<7
Iowa:	Iowa City	31	4	<0.10	<0.10	<0.10	Aug 65	40	<8
Kans:	Topeka	29	3	0.11	<0.10	<0.10	May 65	26	<5
Ky:	Frankfort	29	5	0.14	<0.10	<0.10	Nov 65	36	<14
La:	New Orleans	31	3	0.14	<0.10	<0.10	Nov 65	31	<6
Maine:	Augusta	31	11	<0.10	<0.10	<0.10	Dec 65	113	<23
	Presque Isle	11	7	<0.10	<0.10	<0.10	Aug 65	72	<14
Md:	Baltimore	20	6	0.13	<0.10	<0.10	Jul 65	32	<7
	Rockville Lab	13		0.11	<0.10	<0.10	Oct 65	—	
Mass:	Lawrence	31	7	<0.10	<0.10	<0.10	Feb 66	49	<10
	Winchester	30	5	<0.10	<0.10	<0.10	Sep 65	42	<8
Mich:	Lansing	31	8	0.12	<0.10	<0.10	Oct 65	46	<9
Minn:	Minneapolis	20	3	<0.10	<0.10	<0.10	Feb 66	34	<7
Miss:	Jackson	26	1	0.16	<0.10	<0.10	Dec 65	34	<7
Mo:	Jefferson City	31	5	<0.10	<0.10	<0.10	Jan 66	76	<15
Mont:	Helena	30	2	0.13	<0.10	<0.10	Sep 65	3	<1
Nebr:	Lincoln	18		0.16	<0.10	<0.11	Jan 66	—	
Nev:	Las Vegas	29		0.18	<0.10	<0.11	Jun 65	—	
N. H:	Concord	18		0.12	<0.10	<0.10	Nov 65	—	
N. J:	Trenton	30	4	0.12	<0.10	<0.10	Dec 65	9	<2
N. Mex:	Santa Fe	27	3	0.11	<0.10	<0.10	Sep 65	42	<8
N. Y:	Albany	18	7	0.11	<0.10	<0.10	Jan 66	46	<9
	Buffalo	26		0.17	<0.10	<0.11	Aug 65	—	
	New York	31		0.11	<0.10	<0.10	Sep 65	—	
N. C:	Gastonia	31	6	0.13	<0.10	<0.10	Aug 65	57	<11
N. Dak:	Bismarck	28	1	0.12	<0.10	<0.10	Nov 65	15	<3
Ohio:	Cincinnati	21		<0.10	<0.10	<0.10	Feb 66	—	
	Columbus	29	11	0.16	<0.10	<0.11	Dec 65	117	<23
	Painesville	30	10	0.15	<0.10	<0.10	Jul 65	107	<22
Okla:	Oklahoma City	30	1	0.14	<0.10	<0.11	Oct 65	17	<3
	Ponca City	27	1	<0.10	<0.10	<0.10	Jul 65	5	<1
Ore:	Portland	31	8	0.26	<0.10	<0.14	Jan 66	44	<9
Pa:	Harrisburg	30	5	<0.10	<0.10	<0.10	Jan 66	72	<14
P. R:	San Juan	22	1	<0.10	<0.10	<0.10	Dec 65	28	<6
R. I:	Providence	28	6	<0.10	<0.10	<0.10	Oct 65	67	<13
S. C:	Columbia	29	5	0.11	<0.10	<0.10	Sep 65	12	<2
S. Dak:	Pierre	31	1	0.12	<0.10	<0.10	Jul 65	12	<2
Tenn:	Nashville	31	5	0.11	<0.10	<0.10	Oct 65	36	<7
Tex:	Austin	30	4	0.14	<0.10	<0.10	Feb 66	92	<19
	El Paso	29	1	0.18	<0.10	<0.11	Nov 65	4	<1
Utah:	Salt Lake City	31	1	0.20	<0.10	<0.11	Dec 65	13	<3
Vt:	Barre	30	13	<0.10	<0.10	<0.10	Jun 65	58	<12
Va:	Richmond	31	5	<0.10	<0.10	<0.10	Jun 65	36	<7
Wash:	Seattle	31	8	<0.10	<0.10	<0.10	May 65	34	<7
	Spokane	31		0.15	<0.10	<0.11	Feb 66	—	
W. Va:	Charleston	30	6	0.15	<0.10	<0.10	Sep 65	55	<11
Wis:	Madison	30	7	<0.10	<0.10	<0.10	Jun 65	58	<12
Wyo:	Cheyenne	31	2	0.13	<0.10	<0.10	Jun 65	22	<4
Network summary		1,855	256	0.31	<0.10	<0.10		45	<9

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.
[b] No report received.
[c] Dash indicates no precipitation sample collected.

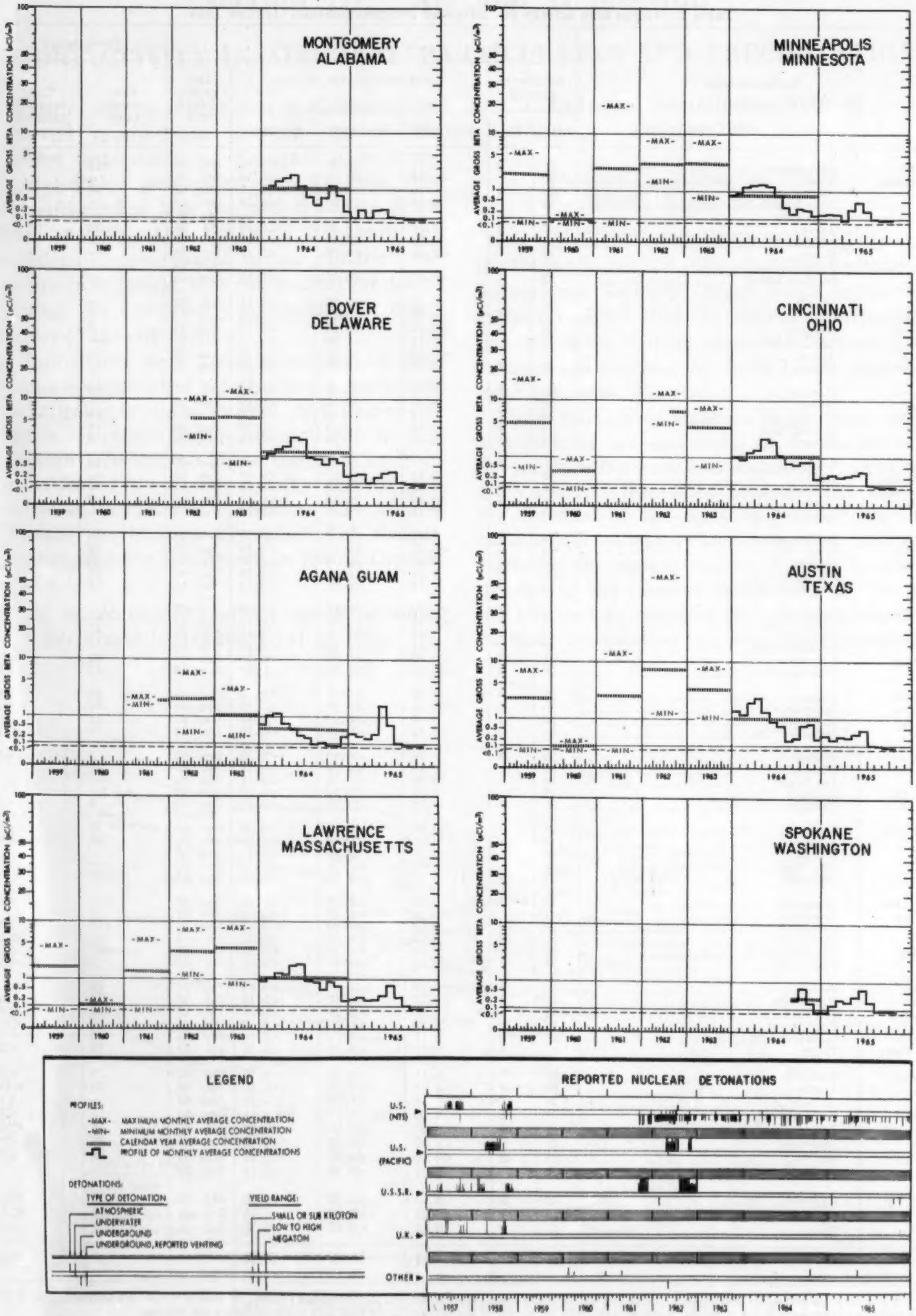

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–October 1965

and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during October 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 298 air samples. Traces of longer-lived products such as manganese–54, zinc–65, ruthenium-rhodium–106, antimony–125, cesium–137, and cerium-promethium–144 were identified in most of these.

2. Canadian Air and Precipitation Monitoring Program[1] October 1965

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for October 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

Table 2. Canadian gross beta activity in surface air and precipitation, October 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity (pCi/m^3)			Average concentration (pCi/liter)	Total deposition (nCi/m^2)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	110	1.3
Coral Harbour	31	0.1	0.0	0.0	56	0.7
Edmonton	31	0.1	0.0	0.1	131	0.7
Ft. Churchill	28	0.1	0.0	0.0	51	2.4
Ft. William	30	0.1	0.0	0.1	65	1.6
Fredericton	31	0.1	0.0	0.0	41	2.6
Goose Bay	30	0.1	0.0	0.0	27	1.9
Halifax	31	0.1	0.0	0.1	33	3.2
Inuvik	30	0.1	0.0	0.0	24	0.6
Montreal	29	0.1	0.0	0.1	28	3.6
Moosonee	31	0.1	0.0	0.0	32	3.4
Ottawa	31	0.1	0.0	0.1	23	3.0
Quebec	30	0.1	0.0	0.0	14	2.5
Regina	30	0.1	0.0	0.1	(a)	0.4
Resolute	13	0.1	0.0	0.0	125	1.9
St. John's, Nfld	28	0.1	0.0	0.0	35	3.6
Saskatoon	30	0.1	0.0	0.1	(a)	0.6
Sault Ste. Marie	30	0.1	0.0	0.1	29	2.7
Toronto	31	0.1	0.0	0.1	30	2.9
Vancouver	31	0.1	0.0	0.1	27	4.1
Whitehorse	31	0.1	0.0	0.0	24	0.8
Windsor	31	0.1	0.0	0.1	15	1.5
Winnipeg	31	0.1	0.0	0.1	91	1.3
Yellowknife	29	0.1	0.0	0.0	41	1.0
Network summary	709	0.2	0.0	0.1	48	2.0

[a] Trace

Table 3. Radionuclide deposition, nCi/m^2, in Canadian fallout, October 1965

Station	^{90}Sr	^{137}Cs
Calgary	0.10	0.14
Coral Harbour	0.05	0.10
Edmonton	0.05	0.06
Ft. Churchill	0.31	0.42
Ft. William	0.13	0.20
Fredericton	0.28	0.32
Goose Bay	0.13	0.18
Halifax	0.24	0.41
Inuvik	0.00	0.07
Montreal	0.35	0.46
Moosonee	0.22	0.30
Ottawa	0.29	0.35
Quebec	0.22	0.24
Regina	0.00	0.12
Resolute	0.09	0.20
St. John's, Nfld	0.25	0.37
Saskatoon	0.03	0.06
Sault Ste. Marie	0.30	0.23
Toronto	0.23	0.43
Vancouver	0.32	0.46
Whitehorse	0.06	0.14
Windsor	0.12	0.16
Winnipeg	0.12	0.11
Yellowknife	0.06	0.13

[a] Samples from all stations are routinely analyzed for strontium-89, strontium-90, and cesium-137; samples from five selected stations are regularly analyzed for zirconium-95 and barium-140. Strontium-89, zirconium-95 and barium-140 are not reported due to insignificant levels.

[1] Prepared from information and data in the October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

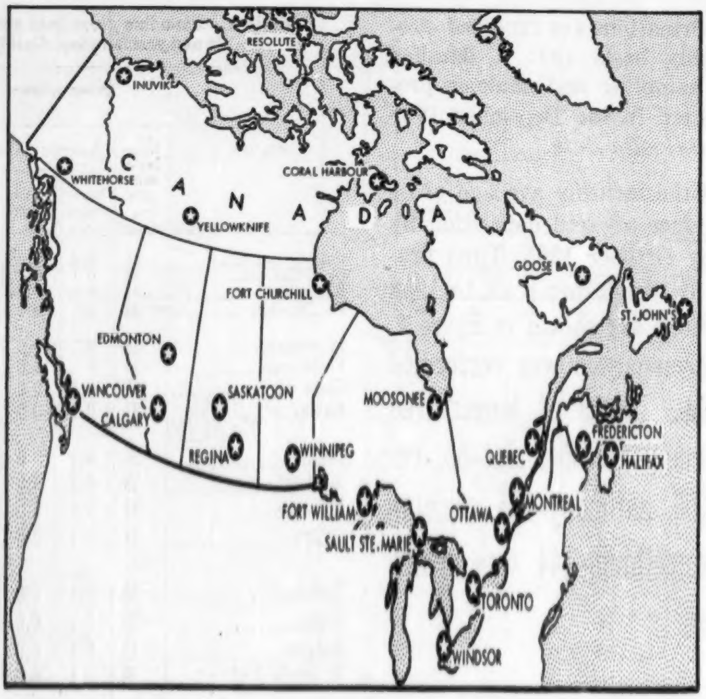

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Monitoring Program October 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico is operated by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961, an earlier network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

The new Radiation Surveillance Network, operated by CNEN's Division of Radiological Protection, consists of 17 stations (see figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are operated by staff members of other agencies.

Details of sampling procedures were outlined in the December 1965 issue of *Radiological Health Data.*

Table 4 presents the maximum, minimum, and average gross beta activity concentrations in surface air during October.

Figure 4. Mexican air sampling station locations

Table 4. Mexican gross beta activity of airborne particulates, October 1965

Station	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.1	<0.1	<0.1
Ciudad Juárez	11	0.2	<0.1	0.1
Chihuahua	17	0.2	<0.1	0.1
Enseñada	13	0.2	<0.1	0.1
Guadalajara	5	<0.1	<0.1	<0.1
Guaymas	8	0.1	<0.1	0.1
La Paz	7	0.1	<0.1	0.1
Matamoros	19	<0.1	<0.1	<0.1
Mazatlán	8	0.1	<0.1	0.1
Mérida	15	0.1	<0.1	<0.1
México, D.F.	14	0.1	<0.1	<0.1
Nuevo Laredo	1			
San Luis Potosí	10	0.1	<0.1	<0.1
Tampico	20	0.1	<0.1	<0.1
Torréon	25	0.2	<0.1	0.1
Tuxtla Gutiérrez[a]				
Veracruz	18	0.1	<0.1	<0.1

[a] Station temporarily shut down.

4. Pan American Air Sampling Program October 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological heath programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

The October 1965 air monitoring results from the participating countries were all below the reportable limit of 0.10 pCi/m³.

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(*11*) ALBA, F., T. A. BRODY, and A. PALACIOS. Cuarto informe sobre estudios de la precipitacion radiactiva. Revista Mexicana de Física 8:61–85 (1959).

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Figure 5. Pan American Air Network sampling stations

Other Programs Covered in *Radiological Health Data and Reports:*

Program	Period	Issue
HASL Fallout Network	April-December 1964	*September 1965*

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such typical data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Hanford Atomic Products Operation, the Pinellas Peninsula Plant, the Savannah River Plant, and the Shippingport Atomic Power Station.

1. Hanford Atomic Products Operation[2] Calendar Year 1964

General Electric Company
Richland, Washington

An evaluation of the results obtained from the Hanford environmental surveillance program for 1964 indicates that most of the environmental radiation exposure for the majority of persons living in the neighborhood of the Hanford project was due to natural sources and worldwide fallout rather than to Hanford operations.

Of the low-level wastes that are released to the environment from the Hanford plants, neutron-induced radionuclides present in reactor cooling water discharged to the Columbia River continued to be the source of greatest potential exposure above background to people in the environs. The primary mechanisms of exposure from this source are drinking water derived from the river, consumption of fish and waterfowl which inhabit the river, and foodstuffs grown on land irrigated with water pumped from the Columbia downstream from Hanford.

Residents of Richland were supplied throughout the year with drinking water from a new treatment plant that draws water from the Columbia River. The radiation exposure from drinking this water was estimated to be about 10 percent of the appropriate limit. The gastrointestinal tract is the limiting organ for the mixture of radionuclides present in drinking water pumped from the Columbia River. In Pasco and Kennewick, which are further downriver, the estimated exposures from drinking water were respectively about 5 percent to 1 percent of the limit for the GI tract. The only persons who received radiation exposures attributable to Hanford that were greater than those that resulted from the drinking water were the people who ate local fish or waterfowl or who regularly consumed produce from nearby farms irrigated with water taken from

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from Pacific Northwest Laboratory, "Evaluation of Radiological Conditions in the Vicinity of Hanford for 1964," BNWL–90 (July 1965).

the Columbia River below the reactors.

The highly unlikely but plausible combination of circumstances that would result in the greatest exposure to an individual from the radionuclides released by the Hanford plants is postulated as (1) the consumption of some 200 meals per year (4 meals per week) of fish caught downstream from the reactors, (2) the consumption of meat, milk, fruit, and vegetables grown on irrigated farms in the Riverview District, and (3) the consumption of drinking water from the Pasco system.

An individual with such habits could conceivably ingest enough radioactive materials of Hanford origin (mostly phosphorus-32) to supply about 25 percent of the annual permissible amount. For this "maximum" individual the bone is the most restrictive organ. This same individual could also ingest enough strontium-90 of worldwide fallout origin to equal about 2 percent of the permissible amount—substantially less than the amount estimated for 1963.

Iodine-131 in the Hanford environs remained at very low concentrations in 1964. The Chinese nuclear test on October 16 caused a brief increase in iodine-131, but concentrations soon returned to the low levels experienced during most of 1964. The postulated "maximum" exposure from iodine-131 to the thyroid of a small child amounted to only about 5 percent of the Radiation Protection Guide recommended for individuals by the Federal Radiation Council.

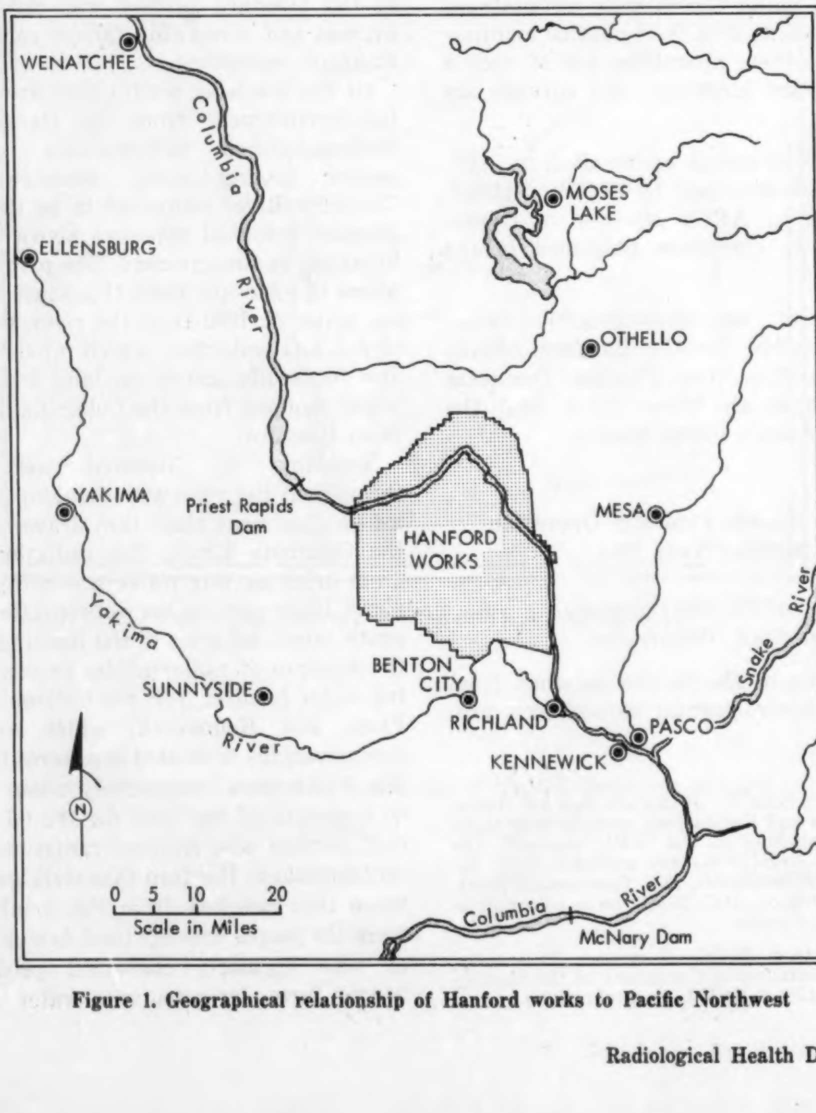

Figure 1. Geographical relationship of Hanford works to Pacific Northwest

The Hanford project[3] (figure 1) is located in a semiarid region of Southeastern Washington State where the average annual rainfall is about 7 inches. This section of the State has a sparse covering of natural vegetation, primarily suited for grazing, although large areas near the project have gradually been put under irrigation during the past few years. The plant site covers an area of about 500 square miles. The Columbia River flows through the northern edge of the project and forms part of the eastern boundary. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions. Near the plant production sites the prevailing winds are from the northwest with strong drainage and cross winds causing distorted flow patterns.

The populated areas of primary interest are the Tri-Cities (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello, and these, together with the surrounding agricultural area, bring the total population near the plant to about 80,000 people.

During the course of operation, various radioactive wastes are generated by the several plant facilities. High level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage are not feasible or necessary, are made to the ground. The Hanford practices governing radioactive waste disposal are described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Congressional Committee on Atomic Energy in 1959. (*1*)

The AEC Manual Chapters (*2*), and the recommendations of the Federal Radiation Council (FRC) (*3*), the National Council on Radiation Protection and Measurements (NCRP) (*4*), the International Commission on Radiological Protection (ICRP) (*5*), and the results of Hanford research programs form the basis of radiation protection practices at Hanford. The recommendations of these organizations in the form of permissible rates of intake of specific nuclides and guides for radiation exposure constitute criteria against which radiation exposures estimated from measurements of the Hanford environmental surveillance program are compared. The results of these comparisons indicate the effectiveness of Hanford waste control and radiation protection practices and point out any conditions requiring attention.

This report presents estimates of the annual exposure received by the individuals judged to have received the greatest amount of radiation from environmental sources and the exposure received by people who are considered typical of this region. These exposures are compared with the recommendations of the FRC and NCRP. The Radiation Protection Guides established by the FRC for individuals are 1,500 mrem per year to the thyroid, 1,500 mrem per year to the bone, and 500 mrem to the whole body. The Radiation Protection Guides for the "average of a suitable sample of an exposed population group" are one-third of those for individuals. The NCRP recommendation, in the form of maximum permissible exposures for individuals that are not employed in radiation work are 1,500 mrem/year to the GI tract, 500 mrem/year to the total body, and 3,000 mrem/year to the thyroid. The limits for bone-seeking nuclides are calculated with reference to biological effects observed from deposition of radium and are most readily applied in the form of maximum permissible rates of intake (MPRI).[4]

Environmental conditions

A discussion and interpretation of the results of the several Hanford environmental sampling programs are presented in the following text and tables.

Radionuclides in the Columbia River

Hanford's eight production reactors and the new N-Reactor use Columbia River water for

[3] Operated during 1964 for the Atomic Energy Commission by the General Electric Company.

[4] The MPRI is taken as the maximum permissible concentration in water for a given radionuclide, as recommended by the NCRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake defined for the standard man. This amounts to one-tenth of the MPC's for continuous exposure of occupational workers multiplied by 2,200 cc per day, or by 800 liters/year in the case of annual estimates.

cooling. The new N-Reactor was operated according to a power ascension program during 1964. The old production reactors circulate water once through as a coolant before it is returned to the river, the new reactor uses recirculating demineralized water as a primary coolant. Only a very small amount of radionuclides generated in auxiliary systems, such as the control-rod cooling water, are released to the river. At the old reactors, stable elements present in the cooling water are transformed into radionuclides during passage through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and channels are eventually carried away by the cooling water to the river. One of the old production reactors, 105–DR, was shut down permanently on December 30, 1964. Two additional reactors, 100–F and 100–H were shut down in April and June 1964, respectively.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some portion of the radionuclides is removed from the water by sediments and by uptake by aquatic organisms. The radionuclides in the river also include some contribution of fallout from weapons tests.

The sampling program for Columbia River and sanitary water was generally revised during 1964. The major changes were a shift from Pasco to Richland as the principal river monitoring point and a change from occasional "grab" samples to cumulative samples at several locations. Yearly averages, where shown, are weighted averages of the best data available.

Samples of river water were collected above the production areas at Vernita Ferry, and below the production areas at the Richland and Pasco water plant intakes, McNary Dam, the Dalles Dam, and Bonneville Dam. Routine sample collection at Vancouver, Washington, was discontinued during the first half of 1964 and replaced by the Bonneville Dam sampling site. Where possible, cumulative sampling equipment was installed which provided a more representative sample than the infrequent "grab" samples obtained in the past. This sampling technique, however, makes it impractical to calculate the amounts of very short-lived nuclides, and these must still be measured from "grab" samples. The average concentrations of radionuclides measured routinely at Richland, Pasco, and Bonneville Dam are shown in table 1.

Table 1. Annual average concentrations of several radionuclides in Columbia River water–1964

(Units of pCi/liter)

Radionuclides	Richland	Pasco	Bonneville Dam
Total beta	(16 counts/min/ml)	[a] —	—
RE+Y [b]	520	230	—
Sodium-24	3,500	1,500	—
Phosphorus-32	300	200	28
Chromium-51	12,000	6,800	2,400
Copper-64	5,300	2,100	—
Zinc-65	450	240	63
Arsenic-76	1,200	670	—
Strontium-90	1	1	—
Iodine-131	19	12	<5
Neptunium-239	2,600	1,300	—

[a] Dash indicates insufficient sampling data to provide a reasonable annual average.
[b] Rare earths plus yttrium.

Measurements on a traverse across the river at Richland indicated slightly nonuniform distribution of the longer-lived radioisotopes throughout the river at this point. At Pasco, the distribution was also slightly nonuniform primarily because of the entry of the Yakima River some 10 miles upstream. Similarly, the distribution of radionuclides at McNary Dam is influenced by the Snake River whose confluence with the Columbia River is about 30 miles above the dam. The Dalles Dam and Bonneville Dam are approximately 190 miles and 240 miles, respectively, below the Hanford reactors and represent the farthest downstream locations where river water is routinely sampled for Hanford's environmental surveillance program.

There is no known instance of untreated river water being consumed routinely by humans. For comparative purposes, however, the relationship between the concentrations of radionuclides in untreated Columbia River water and "maximum permissible concentrations" in water is shown in table 2. In this instance, the comparison is with the MPC's listed in column 2, table II of annex I of AEC Manual chapter appendix 0524 (*2*). For the most part, these MPC's are equivalent to one-tenth of the most limiting values recommended by the NCRP (*4*) for occupational workers. The marked reduction in percent of MPC_w that occurs with distance downstream from the reactors results principally from radioactive decay of the shorter-lived nuclides.

Table 2. Relationship between the concentrations of radionuclides in untreated Columbia River water and maximum permissible concentrations

Sampling location	MPC, percent [a]
Richland	15
Pasco	7
Bonneville Dam	<1

[a] This is a summation of the percents of MPC's contributed by the several individual radionuclides measureed routinely in the river water. The MPC's used and the method of summation are taken from AEC Manual Chapter 0524.

Radionuclides in drinking water

The city of Richland is the first community downstream from the Hanford reactors to use the Columbia River as a source of sanitary water supply. The year 1964 was the first full year of operation for Richland's new water treatment plant. Previously, Richland's sanitary water was obtained from wells, but now these wells are used only during peak demand periods. Pasco and Kennewick, a few miles further downstream, continued to use the Columbia River as a source of sanitary water during 1964. Continuous sanitary water samples were collected at the Richland water plant and periodic sampling was accomplished at Pasco and Kennewick. All of these samples were analyzed for the important individual radionuclides. The results of the radioanalysis of water from these three cities are summarized in table 3.

Table 3. Annual average concentrations of several radionuclides measured in sanitary water–1964

(Units of pCi/liter)

Radionuclides	Richland	Pasco	Kennewick
Total Beta	(10 counts/ min/ml)	(3.4 counts/ min/ml)	(0.54 counts/ min/ml)
RE+Y [a]	70	60	10
Sodium-24	2,500	700	150
Phosphorus-32	40	40	<10
Chromium-51	8,000	6,000	3,000
Copper-64	2,000	400	90
Zinc-65	90	70	<20
Arsenic-76	450	200	<50
Strontium-90	2	1	<0.5
Iodine-131	10	8	<3
Neptunium-239	2,000	450	50

[a] Rare earths plus Neptunium.

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than shown in table 3 because there is a significant flow time between the water plant and most consumers. The flow time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand.

Table 4 shows the apparent removal of several radionuclides by water treatment at Pasco and Richland. These data include the radioactive decay of the short-lived radionuclides during travel through the water treatment plant.

Table 4. Depletion of radionuclides from Columbia River water by treatment at the Richland and Pasco water plants–1964

Radionuclides	Depletion, percent	
	Pasco	Richland
RE+Y [a]	80	90
Copper-64	80	70
Arsenic-76	70	70
Zinc-65	70	80
Phosphorus-32	60	90
Sodium-24	50	30
Neptunium-239	40	30
Chromium-51	10	30

[a] Rare earths plus yttrium.

The calculated annual average dose to the GI tract, total body, and the percentage MPRI for bone from sustained consumption of sanitary water throughout the year at the three cities is presented in table 5.

The dose received by the GI tract of Pasco residents continued at approximately the same level as experienced during 1963. The dose received by the GI tract of Richland residents was somewhat lower in 1964 than was predicted from the initial results obtained following start-up of the new water treatment plant in the latter part of 1963.

Table 5. Calculated annual dose for selected organs from routine ingestion of sanitary water–1964 [a]

Location	Total body, mrem	GI tract, mrem	Bone percent, MPRI	Thyroid (small child, 1 liter/day), mrem
Richland	3.5	50	1	75
Pasco	<2	20	0.8	40
Kennewick	<1	<5	<0.5	<20

[a] Here and elsewhere in this report where a dose from an ingested nuclide is expressed in mrem units, the determination is made from parameters used by the ICRP to translate dose rates into Maximum Permissible Concentrations for drinking water. In most cases, the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart, et al.(8)

The "standard man" (6) average intake of 1.2 liter/day was used in this calculation.

Radionuclides in fish and waterfowl

The Columbia River is popular for sport fishing both above and below the Hanford plant, and the fish that feed downstream from the reactors acquire some radionuclides from the

reactor effluent. Whitefish are the sport fish that usually contain the greatest concentration of radioactive materials, and phosphorus–32 is the radionuclide of greatest significance. Further, they can be caught during winter months when other sports fish are difficult to sample. For these reasons, whitefish are sampled most intensively to follow trends.

Usually the peak concentrations of phosphorus–32 in whitefish occur during the fall months. During 1964, however, below normal river flow rates in the spring, and below normal river temperatures in the fall, resulted in peak concentrations during the first half of the year. The overall effect of these unusual conditions was an annual average concentration in whitefish of about 470 pCi ^{32}P/g and 37 pCi ^{65}Zn/g virtually the same as in 1963. If whitefish were eaten fresh at the rate of one meal per week (about 25 lb/yr), the intake during 1964 would have been approximately 5 μCi of phosphorus–32 and 0.4 μCi of zinc–65. The resulting exposure would have been about 100 mrem to the GI tract, 40 mrem to the total body, and 30 percent of the MPRI for bone. Many of the fishermen that catch whitefish prefer to smoke them, and radioactive decay of the phosphorus–32 (2-week half-life) during storage of the preserved fish reduces the potential intake of this nuclide.

The quantities and kinds of fish caught by local fishermen have been estimated previously from surveys carried out by personnel of the State of Washington, Department of Game, and no additional dietary data were collected during 1964 that would change these estimates. Those individuals who probably ingest the largest amounts of phosphorus–32 are fishermen who claim to eat bass, crappie, perch, and catfish as often as 3 to 5 times a week. This number of fish meals indicates an annual intake of about 90 pounds of fish. Analyses of these species of fish from locations fishermen claimed to visit most frequently indicated no peak concentration in the spring and generally lower phosphorus–32 concentrations than found in whitefish (used as reference for estimating dose in the preceding paragraph). On the basis of the 90 pounds of fish consumption claimed by the "maximum individual," (approximately 200 fish meals/year), the intake of phosphorus–32 during 1964 could have been approximately 3 μCi.

Many persons have been counted in the Hanford whole body counter, including some avid fishermen. Amounts of zinc–65 detected in these people were much less than expected on the basis of their stated fish consumption. These results supported the findings of 1963 which suggested that fishermen tend to overestimate their fish consumption. Therefore, the actual ingestion rates of both phosphorus–32 and zinc–65 are substantially lower than postulated from the fishermen's estimates.

Migratory waterfowl, such as ducks and geese, that have utilized the Hanford section of the Columbia River and the swamps and ponds within the project boundaries may contain phosphorus–32, zinc–65, and other radionuclides. Some of these waterfowl remain in this general area throughout the year. One hundred and forty-seven samples were collected during the hunting season within the Hanford project and in the environs, and 71 samples were contributed by hunters from areas adjacent to the plant.

Only five samples contributed by hunters contained concentrations of phosphorus–32 greater than the detectable level of 50 pCi/g of flesh (wet weight), and the highest concentration found was 650 pCi/g. Of all waterfowl samples collected in the Hanford environs, about one-third contained detectable levels of phosphorus–32 and about one in ten contained 500 pCi/g or greater. The maximum concentration measured during the hunting season was 1,700 pCi ^{32}P/g of flesh.

Radionuclides in marine organisms

Zinc–65 and phosphorus–32 are the only radionuclides in the reactor effluent that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of zinc–65 than other common seafood organisms. Concentrations of zinc–65 have gradually decreased over the past 2 years while phosphorus–32 concentrations have remained at about the same level. The average concentrations in samples taken periodically throughout the year were 56 pCi ^{65}Zn/g and 4 pCi ^{32}P/g. Consumption of oysters containing these concentrations at the rate of one meal per week (one-half pound) would result in an annual exposure of about 7 mrem to the GI tract, 4 mrem to the whole

body, and about 0.5 percent of the MPRI for bone.

Radionuclides in the atmosphere

At Hanford, gaseous waste from the chemical separations facilities is released to the atmosphere through 200-foot high stacks after most of the radioactive materials have been removed by filters and scrubbers. These radioactive materials are primarily associated with process off-gases. Ventilation air from laboratory and reactor buildings contains comparatively minor amounts of radioactive materials under normal operating conditions.

Iodine–131 is the radionuclide of principal interest in the separations facilities process off-gases. Gross beta measurements are continuously made to detect any change in emission rates of other radionuclides. The results for the past 4 years are summarized in table 6.

Table 6. Annual average emission rates of several radionuclides from separations plant stacks

(curie/day)

Radionuclide	1964	1963	1962	1961
Iodine-131	0.22	0.38	0.35	0.7
Zirconium-niobium-95	[a] —	—	0.0024	0.005
Ruthenium-103	—	—	0.0009	0.003
Ruthenium-106	—	—	0.0036	0.005
Cerium-141	—	—	0.0002	0.006
Cerium-144	—	—	0.015	0.01
Filterable gross beta	0.030	0.013	—	—

[a] Dash indicates insufficient sampling data to provide a reasonable annual average.

The fission product recovery facilities operating at Hanford contributed negligible amounts of radionuclides to the environs during 1964. The average emission rate of strontium–90 from these facilities was less than 0.002 Ci/day.

Measurements of airborne iodine–131 were made routinely at several locations within the Hanford reservation and at several locations around the plant perimeter. The results of iodine–131 measurements for the past few years are summarized in table 7.

The four locations listed in table 7 lie within a 45 degree sector southeast to south of the separations center. The annual average concentrations of iodine–131 in air about the Hanford plant during 1964 were generally 0.05 pCi/m^3 or less. Such concentrations sustained in inspired air imply an annual dose to the thyroid of the "standard man" of less than 1 mrem.

Table 7. Average iodine-131 concentrations in the atmosphere

(Units of pCi/m^3)

Location	Distance from separation stacks, miles	1964	1963	1962	1961
Benton City	20	0.06	0.03	0.08	0.02
Prosser Barricade [a]	14	0.02	—	—	—
Richland	23	0.02	0.02	0.04	0.02
Pasco	32	0.01	0.02	0.08	0.04

[a] Installed during October 1963.
[b] Dash indicates insufficient sampling data to provide a reasonable annual average.

Air sampling stations are maintained at several locations within the Hanford reservation and at several locations situated around the plant perimeter. Early in 1964 the remote sampling stations (Boise and Lewiston, Idaho; Klamath Falls and Meacham, Oregon; Great Falls, Montana; and Seattle, Washington) were discontinued and replaced by stations forming a closer ring about the perimeter of the Hanford reservation. The sampling stations now in operation include Pendleton and McNary Dam, Oregon; Spokane, Walla Walla, Yakima, Moses Lake, Ellensburg, Wenatchee, Sunnyside, and Washtucna, Washington. During the early part of 1964 beta activity on air filters was less than 1 pCi beta/m^3 but increased to about 3 pCi beta/m^3 in May during the spring influx of worldwide fallout. The airborne activity then decreased steadily to less than 1 pCi beta/m^3 except for a very brief period at the end of October when fallout from the Chinese nuclear test caused a slight increase.

Results of air filter measurements are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentration are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

Radionuclides in milk and produce

The radioactivity found in locally grown agricultural produce can be influenced by deposition of airborne radionuclides, or by irrigation with river water containing reactor effluent radionuclides. The chemical separations facilities are generally considered to be

the principal local source of airborne radionuclides. Ventilation stacks of the reactors or laboratory facilities possibly could, under certain conditions, become of some small interest. The closest farming area to the separations facilities is about 13 miles away.

Most irrigated farms near the Hanford plant use water from the Yakima River, or from the Columbia River above the project. There are, however, two small areas which take water regularly from the Columbia River downstream from the reactors for irrigation. They are the Ringold farms and the Riverview district west of Pasco located 15 and 30 miles, respectively, downstream from the reactors. The Ringold farms, approximately 13 miles east of the production areas involve about 20 people working some 500 acres of land with fruit as the principal product. The Riverview farm area consists of about 5,300 acres supporting about 1000 families, the majority of which live on plots of an acre or less and raise family gardens. The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is located 30 miles southeast of the chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles directly south of the separations facilities.

A comprehensive milk surveillance program maintained during 1964 included samples from local farms and dairies and from commercial supplies available to people in the Tri-Cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to those reported by the U.S. Public Health Service and the Washington State Department of Health. Milk from local farms irrigated with water from the river downstream from the reactors contained phosphorus–32 and zinc–65, as well as several fission products of fallout origin.

The average concentration of iodine–131 in both local and commerical milk was at or below the reporting limit of 3 pCi/liter except for a brief increase during the summer months and again briefly following the Chinese nuclear test in the fall. The maximum concentration of iodine–131 observed in milk was 36 pCi/liter on November 10, 1964. Activity levels then decreased rapidly in December to 3 pCi/liter or less.

Concentrations of strontium–90 measured in milk produced locally ranged from less than 2 pCi/liter to 16 pCi/liter. These values are similar to concentrations found in commercial milk produced in areas that are remote from the Hanford plant. Strontium–90 found in milk from local farms averaged about 8 pCi/liter, and a generally decreasing trend was observed throughout the year. Concentrations of strontium–90 and cesium–137 in milk analyzed at Hanford were generally at or below the detection levels of 2 pCi ^{90}Sr/liter and 30 pCi ^{137}Cs/liter. Worldwide fallout is the principal source of these radionuclides in milk.

Dairy farms in the Ringold and Riverview area that utilize the Columbia River for irrigation of pasture land and hay fields produce milk containing both phosphorus–32 and zinc–65. During 1964 the average concentration of phosphorus–32 in milk from these farms was about 1,600 pCi/liter and the concentration of zinc–65 was 550 pCi/liter. The highest concentration of phosphorus–32 in milk (5,700 pCi/liter) was observed during August, a period of heavy irrigation and rapid growth of pasture grass. Commercial milk distributed in the Tri-Cities usually does not contain phophorus–32 and zinc–65 because it is obtained principally from areas not irrigated with Columbia River water.

If the commercially available milk were consumed at the rate of 1 liter/day, the "fallout" radionuclides would contribute an annual average dose of less than 1 mrem to the GI tract, about 4 mrem to the total body, and about 3 percent of the FRC rate of intake guide for bone.[5] Residents consuming milk obtained from the Ringold-Riverview area would receive some additional exposure from phosphorus–32 and zinc–65 amounting to about 12 mrem to the GI tract, 5 mrem to the total body, and about 4 percent of the MPRI for bone.

Miscellaneous fresh farm produce was sampled periodically during the 1964 growing season from local farms and commercial outlets for radioanalysis. Results of these measurements were similar to those of previous years and indicated that only small quantities of radionuclides are present in locally grown products.

[5] The Federal Radiation Council does not consider fallout from the testing of weapons to be from "normal peacetime operations" for which the Radiation Protection Guides were developed.

The concentrations of iodine–131 found on samples of fresh vegetables collected from local farms and markets during the period of May through September were less than or approximately at the detection level of 0.05 pCi/g. There was no significant difference noted in concentrations found on local farm produce and on produce purchased from commercial outlets. If these fresh vegetables had been consumed at the rate of 100 g/day throughout the 5-month growing season, the average annual intake from this source would have been about 750 pCi ^{131}I. Such an intake would imply an annual exposure of about 1 mrem to the thyroid of a "standard man".

Concentrations of iodine–131 in cattle thyroids

The thyroids of cattle are collected periodically from slaughter houses by cooperating veterinarians in Moses Lake, Toppenish, Walla Walla, Wenatchee, and Pasco and sent to Hanford for radioanalysis. Since the concentration of iodine–131 in bovine thyroids is about two orders of magnitude higher than that in the pasture grass or in milk, it is advantageous to use thyroid measurements to follow probable trends in concentrations of iodine–131 in milk and farm produce when the levels in milk and vegetables are too low for practical measurement. The average concentrations measured in beef thyroids were generally at or below the reporting level of 5 pCi ^{131}I/g during most of 1964 except for brief periods in the summer and again following the Chinese nuclear test on October 16. The maximum concentration observed in November was only 60 pCi ^{131}I/g from one sample collected at Pasco. By the end of the year concentrations of iodine–131 in beef thyroids were again near the reporting level of 5 pCi/g.

External radiation

Ionization chambers are stationed on the Hanford reservation and are submerged in the Columbia River to estimate the gamma radiation doses from external sources. Measurements in air over the ground during 1964 averaged about 0.41 mR/day or 105 mR/year, somewhat lower than measured during the past 2 years. Essentially, all of this exposure is from natural background and worldwide fallout from nuclear testing.

Direct radiation measurements are made in the Columbia River at several locations with pocket-type ionization chambers submerged 2 to 5 feet below the surface of the water. Exposure rates are higher in the river than over ground because of the presence of gamma emitters, especially sodium–24, in reactor effluent. In the vicinity of Pasco and Richland the average dose rates in the water during the months of April through October were about 1.5 and 2 mR/day, respectively. A person swimming or boating in the river for a total of 240 hours during the year would receive about 15 mR total body exposure near Pasco and about 20 mR near Richland.

Radiation measurements (*9*) made along the shoreline of the river indicate the exposure rate may be about 0.25 mR/hour from radionuclides deposited with debris and in the mud and sand by fluctuating water levels. If an ardent fisherman were to spend as many as 200 hours fishing along the river's edge, the annual whole body exposure received from these materials would be about 50 mR.

An aerial radiation surveillance program conducted during 1964 included several flight patterns both over the Hanford reservation and the surrounding area. Background gamma radiation measurements were made during these flights over the predesignated ground check points for comparison with previous measurements. No significant changes in radiation levels were detected over the ground covered by these flight patterns.

Radioactive wastes released to ground

Liquid wastes from the chemical separations area are routed to various facilities dependent upon their burden of radionuclides. High level wastes (normally containing concentrations greater than 100 μCi/ml) are stored in underground concrete tanks lined with steel. Intermediate level wastes, ordinarily containing concentrations in the range of 5×10^{-5} μCi/ml to 100 μCi/ml, are sent to underground "cribs" from which they percolate into the soil. The areas selected for intermediate waste disposal and high level waste storage have soil with good ion exchange capacity and depths of 150 to 350 feet to ground water. Low level wastes usually containing less than 10^{-5} μCi/ml are sent to depressions in the ground where surface

ponds or "swamps" have been formed as a result of the continuous addition of the relatively large volumes of water.

One important objective in the management of wastes placed in the ground is the prevention of radiologically important radionuclides from reaching the ground water in quantities that could ultimately cause significant human exposure should they migrate to the Columbia River. For this reason wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and for measuring radionuclides that have reached the ground water. Virtually all of the radionuclides present in the ground water have been introduced with liquids sent to the cribs.

The quantity of radioactive material sent to ground during 1964 (excluding tritium and materials sent to storage tanks) was about 155,000 curies. This is a considerably greater quantity than is normally discharged during a 12-month period and was primarily caused by an accidental discharge of approximately 100,000 curies of fission products to a specific retention facility and a process equipment failure which allowed approximately 10,000 curies to be discharged to an open pond. Neither release will cause significant ground water contamination. The historical total of radioactive materials sent to ground is estimated to be approximately 2,800,000 curies. Because of radioactive decay, the current total is estimated to be only 300,000 curies. In order of abundance, the bulk of the material is ruthenium-106, cesium-137, and strontium-90.

The detectable beta contamination (not including tritium) in the ground water beneath the 200 W Area was less extensive in 1964 than in previous years. This resulted from a reduction in the amount of contaminants discharged to ground, radioactive decay, and further dilution in the ground water.

A substantial amount of tritium has been sent to the ground with the intermediate level liquid wastes from the separations plants.

In all probability, some tritium and ruthenium-106 originating at the chemical processing areas is now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the river water and any exposure from them is negligible.

Radiation exposure

It is not possible to determine the precise radiation exposure received by every individual because of variations in the kind and quantity of food consumed, sources of food supply, and many variations in personal living habits. These inherent variations between individuals require a somewhat subjective approach when estimating the probable radiation exposure in relation to various established limits. The Federal Radiation Council has provided two sets of guides against which exposures from environmental sources may be judged, *i.e.*, one for the individuals that received the greatest exposure, and the other for the average exposure received by the general population (taken as one-third of that set for individuals). For the Hanford environs, exposures from the various sources described in the preceding sections have been compiled in two ways to allow comparisons with guides for both the individual and the general population. In one case a hypothetical, but plausible, individual has been assigned dietary and other habits that would result in what would seem to be the greatest rational exposure. For the general population, an exposure has been estimated for what is called the "average" Tri-City resident. Some residents may receive more exposure than calculated for the "average" Tri-City resident, but very few, if any, receive as much as that calculated for the "maximum" individual. Included in this intermediate group are families that subsist largely on foodstuffs produced on farms irrigated with water taken from the Columbia River downstream from the reactors.

The maximum individual

Attempts have been continued to identify the individuals living in the Hanford environs that receive the greatest exposure. Experience accumulated from the environmental surveillance program indicates such individuals are undoubtedly persons that frequently eat fish caught locally in the Columbia River and foodstuffs grown on farms irrigated with Columbia River water. Additional data collected during 1964 continued to support the assumption that fish, consisting mainly of crappie, perch, bass, and catfish caught near Burbank are the most important source of radionuclides for the "maximum" individual. On the basis of an assumed consumption of 200 meals per year and radiochemical analyses of such fish, the intake of phosphorus-32 for the "maximum" individual during 1964 would have amounted to about 3 μCi (about 20 percent of the NCRP

limit). Whether this amount of fish was actually eaten by the individual was not confirmed. However, other persons reporting an unusually high consumption of local fish were counted in the whole body counter and were found to have far less zinc-65 deposited than predicted on the basis of estimates of the quantities of fish eaten.

A maximum reported consumption of 200 meals/year is used as a basis for calculating the intake of radionuclides from this source. The consumption rates of other foods for the hypothetical "maximum" individual are based on the maximum intakes described in various dietary surveys. It is assumed that this individual consumes each day over 2 quarts of water from the Pasco system, and about 1 quart of milk, ½ pound of beef, and nearly ½ pound of fresh leafy vegetables (in season), all produced on river-irrigated farms in the Riverview District. The exposure amounts to about 10 percent of the appropriate limit for the GI tract, 25 percent of the limit for bone, 1 percent of the limit for the thyroid, and 20 percent of the limit for the total body. Included with the estimate of total body exposure is 50 mR received from the river bank while fishing. The estimated exposure to the total body from strontium-90 is more than was actually received because the method of calculation assumes that the rate of intake experienced in 1964 had been sustained for many years.

In the case of the thyroid gland, it is possible that the maximum exposure occurred in small children because of the relatively small thyroid mass in which the iodine-131 accumulates. The thyroid of a small child is assumed to weigh 2 grams compared with 20 grams for the adult. On the basis of a daily intake of 1 liter of milk, 50 grams of fresh, leafy vegetables produced in the Riverview District, and 0.8 liter of water from the Pasco system, the estimated annual intake of iodine-131 was about 4,400 pCi for a small child in 1964. Such an intake would result in a thyroid dose of 75 mrem or 5 percent of the FRC Radiation Protection Guide for individuals.

The average Tri-City resident

The vast majority of people who live in Richland, Pasco, and Kennewick obtain their food from local commercial stores (rather than directly from farms) and consume little or no fish caught from the Columbia River. The principal sources of radionuclides to these people are worldwide fallout and drinking water from the Columbia River. It is assumed that the contribution from fallout of iodine-131 and strontium-90 is the same in all three cities. The intake of strontium-90 is estimated with the use of data obtained from dietary surveys made elsewhere in the United States and reported by the Federal Radiation Council, (*3*) but adjusted on the basis of the concentration in milk sold in local stores during 1964. The estimated annual intake of strontium-90 during 1964 was about 0.006 μCi, approximately 8 percent of the FRC guide for the general population exposed to strontium-90 from normal peacetime sources.

The contribution from Hanford-created radionuclides in drinking water is substantially different for the three cities as discussed previously. In Richland, the GI tract exposure was greater than in the cities further downriver because the short-lived nuclides are in greater abundance. As shown in table 5, the estimated exposure for 1964 was about 50 mrem or 10 percent of the population limit. This exposure is significantly below that predicted on the basis of data collected in the last quarter of 1963 following startup of the new water treatment plant. The contribution to the GI tract dose from other sources was relatively insignificant and, conversely, the concentration of bone seekers, such as phosphorus-32 and strontium-90, in water was so low that drinking water did not contribute any significant dose to the bone.

For dose to the thyroid gland, the most appropriate sample of the exposed population would appear to be small children living in Richland who drank water from the municipal system (0.4 liter/day), milk (0.6 liter/day) obtained from the local stores, and fresh vegetables (25 g/day) obtained from local markets. The total intake of iodine-131 during the year from these sources would be about 2,600 pCi or an average of about 7 pCi/day. This is in the middle of the FRC Range I.

The estimated total body exposure of the average Richland resident from artificial radionuclides was about 12 mrem, the major portion of which was assigned to strontium-90 from fallout. The method used to calculate the dose

from strontium-90 yields a value that is unrealistically high, however, because the parameters used are based on equilibrium conditions which would exist in the body only after many years of ingesting strontium-90 at the rate estimated for 1964. The contribution to total dose by nuclides of Hanford origin (principally sodium-24 and zinc-65) ingested mainly with drinking water was estimated at about 3 mrem. This total body exposure may be compared with the FRC guide of 170 mrem for the average of a suitable sample of an exposed population. Exposure from natural background sources (excluded from the FRC guide) in this region is estimated at about 150 mrem/year.

Conclusions

During 1964 the environmental surveillance program of the Hanford environs again showed that the amounts of radioactive materials present were well within nationally accepted limits at all times, and that releases of radioactive wastes were well controlled.

Phosphorus-32 released to the Columbia River in reactor effluent continued to be the most significant source of exposure from the Hanford project. This phosphorus-32 is concentrated by fish that inhabit the river downstream from the reactors. Individuals who regularly eat such fish as a major part of their diet throughout the year could conceivably have taken in as much as 20 percent of the annual permissible amount of this bone seeker. Other foods, such as milk, and other nuclides, such as strontium-90 from fallout could have increased the total intake of bone seekers by this "maximum individual" to as much as 25 percent of the annual limit. The use of similar dietary assumption last year resulted in an estimate of 50 percent for 1963.

There were no unusual releases of radionuclides from the Hanford plants during 1964 that warranted special assessment of the radiation dose to persons in the environs. The deposition of strontium-90 from worldwide fallout was significantly less in 1964 than in 1962 or 1963 and, consequently, this nuclide contributed less exposure.

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Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1959 and first and second quarters of 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*October 1962*
Calendar year 1962	*January 1964*
Calendar year 1963	*January 1965*

2. Pinellas Peninsula Plant January–June 1965[6]

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 2, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Environmental monitoring includes sampling of a single combined sewer effluent, milk from three local dairy farms, and air and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples, which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

[6] Summarized from "Environmental Monitoring, January 1 through June 30, 1965", General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Florida.

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the one sample collected during the sampling period revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pCi/m^3 for tritium gas and 5,000 pCi/m^3 for tritium oxide.

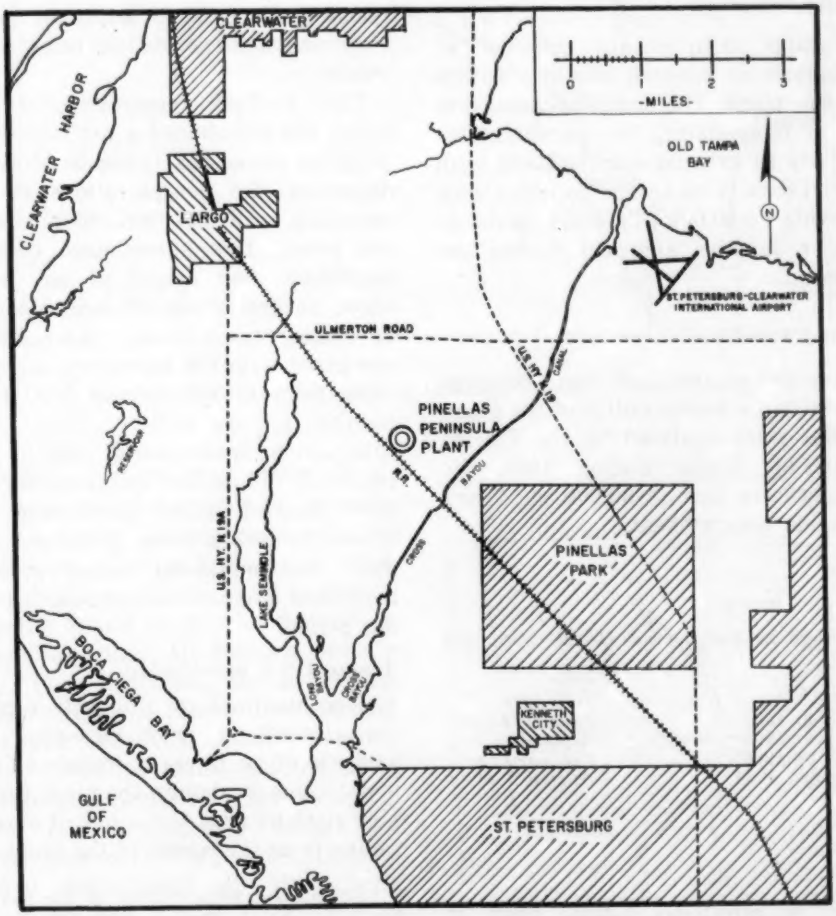

Figure 2. Location of the Pinellas Peninsula Plant

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 5 of 125 samples analyzed showed detectable concentrations of tritium (>90,000 pCi/liter).[7] The maximum concentration, 630,000 pCi/liter, was caused by radioactivity in the cooling water discharged from the plant's incinerator during the burning of low level contaminated wastes. Calculations based on radioactivity releases from the process waste system, the incinerator, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1965 was less than 1.52 percent of the radioactivity concentration guide for continuous nonoccupation exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (>90,000 pCi/liter) in the 46 surface water samples analyzed during the sampling period.

Milk sampling results

Fifteen samples of raw milk were collected from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1965. No detectable concentrations (>90,000 pCi/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1960–1961	*July 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
January–June 1964	*February 1965*
July–December 1964	*August 1965*

[7] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

3. Savannah River Plant[8] January–June 1965

E.I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a fuel preparation area, four operating reactors, two fuel separation areas, and a heavy water production plant. The fifth production reactor and the heavy water component test reactor were closed down permanently in 1964. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (prior to plant startup) to determine the concentrations of radioactive materials in a 1,200-square-mile area outside the plant. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) in the AEC Manual (see footnote 1, page 113).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Maximum and minimum values given are for individual samples collected during the reporting period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations located on the plant perimeter and nine stations around a circle of about 25 miles radius from the center of the plant (figure 3).

[8] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1965." (DPST-65-30-2).

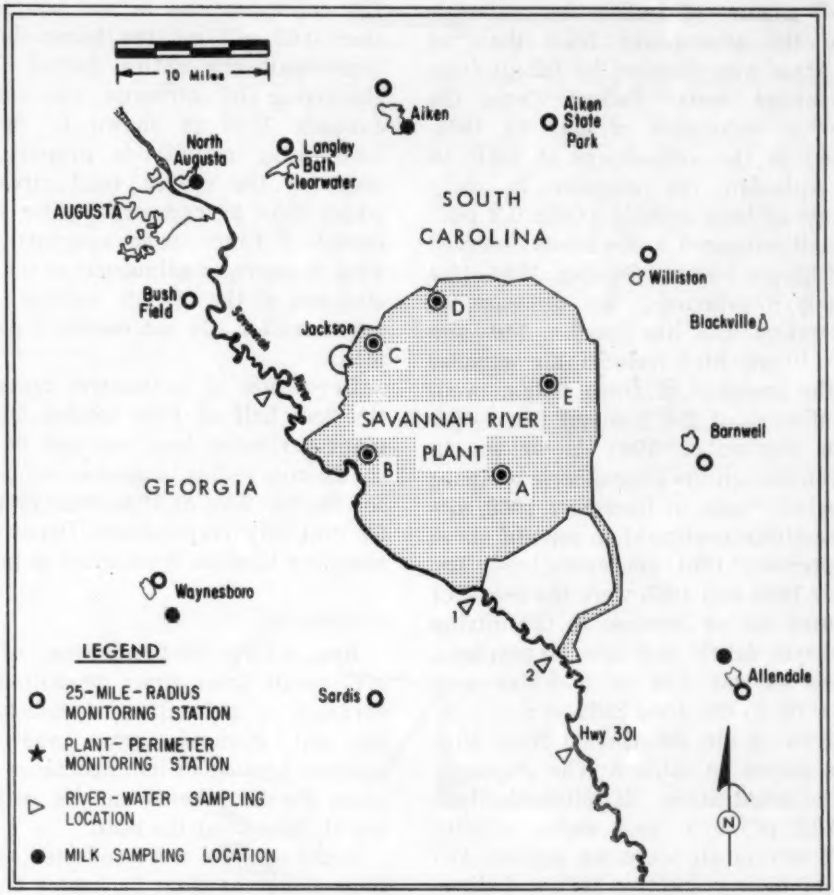

Figure 3. Environmental sampling locations, Savannah River Plant

Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that the effect of SRP operations is negligible; they are reference points for determining background activity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

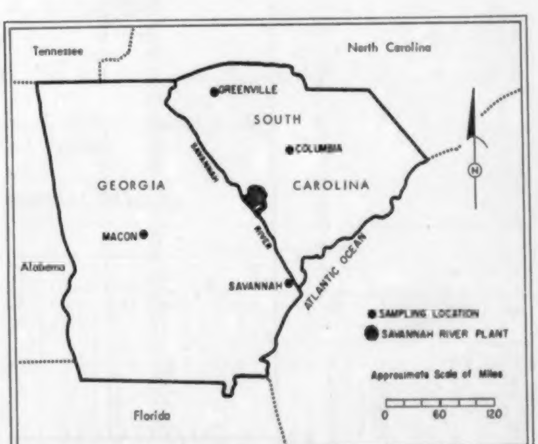

Figure 4. Distant air monitoring stations, Savannah River Plant

The small amount of radioactive materials released to the atmosphere from the fuel separation areas was obscured by fallout from nuclear weapons tests. Fallout from the Chinese nuclear detonation of May 14, 1965, was detected in the atmosphere at SRP on May 27. Although the increase in daily measurements of beta activity (from 0.2 pCi/m³) was small compared to the levels observed after the Chinese test in October 1964 (2.4 pCi/m³, daily maximum), the presence of short radioactive half-life barium–140 and lanthanum–140 on high volume air samples confirmed the presence of fresh fission products. The influence of the weapons test which resumed in September 1961 is shown in figure 5. Even though the atmospheric weapons test moratorium began in December 1962, airborne radioactivity continued to remain above the pre-September 1961 concentrations. The rises in early 1964 and 1965 were the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere. The Chinese nuclear test in mid-May contributed slightly to the June 1965 level.

Radioactivity in air, determined from filter analyses, is shown in table 8. The January–June 1965 concentrations of filterable beta activity (0.22 pCi/m³), and alpha activity (0.0007 pCi/m³) in air were 0.2 percent and 1.8 percent of their respective MPC's. Iodine-131 concentrations in air samples were less than 0.02 pCi/m³, the lower detection limit throughout the entire period. The relative abundance of airborne radionuclides since January 1963 is shown in figure 6. The diminishing activity is proportional to the areas of the circles (and circle segments) which show average activity for each 6-month period. Tritium oxide concentrations in air were measured continuously at the plant perimeter and at the 25-mile stations; the average concentration did not exceed 2 percent of the MPC.

Deposition of radioactive materials during the first half of 1965 totaled 56 mCi/mi² at plant perimeter locations and 64 mCi/mi² at the 25-mile radius locations; comparable values for the last half of 1964 were 69 mCi/mi² and 65 mCi/mi², respectively. Deposition at each sampling location is recorded in table 9.

Vegetation

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or absorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples were collected at seven locations along the plant perimeter and at 7 other

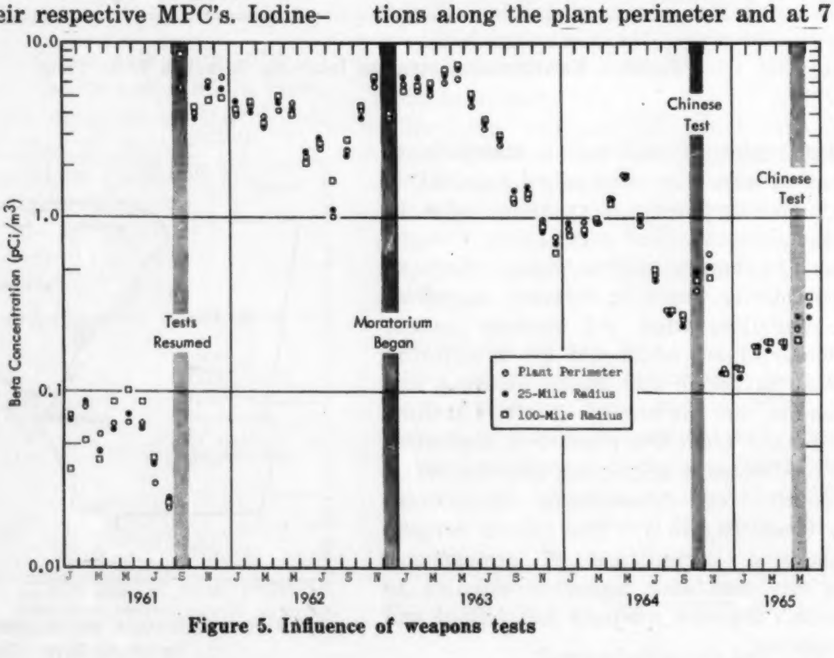

Figure 5. Influence of weapons tests

Table 8. Radioactivity in air, pCi/m³

(Filter analyses)

	Plant-perimeter locations															
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
Alpha emitters in air [a] (multiply by 10^{-3})																
Maximum	1.4	1.8	1.8	1.1	1.8		1.5	1.1	1.5	2.5	1.1	1.8	1.7	2.0	5.4	
Minimum	0.3	0.4	0.3	ND	ND		0.3	ND	ND	0.3	ND	0.3	ND	0.3	ND	
Average	0.7	0.9	0.8	0.6	0.6	0.7	0.8	0.6	0.7	0.9	0.5	0.9	0.7	0.7	0.8	0.7
Nonvolatile beta emitters in air [b]																
Maximum	0.49	0.50	0.48	0.43	0.46		0.36	0.47	0.55	0.47	0.53	0.52	0.69	0.55	0.50	
Minimum	0.01	0.09	0.11	0.11	0.10		0.05	0.08	0.13	0.03	0.05	0.09	0.10	0.11	0.10	
Average	0.24	0.24	0.23	0.22	0.23	0.23	0.20	0.21	0.23	0.19	0.20	0.21	0.22	0.23	0.21	0.21
Specific radionuclides in air (averages)																
Cesium-137				0.02							0.02					
Cerium-144				0.04							0.05	25-miles				
Ruthenium-106				0.03							0.03	radius				
Zirconium-Niobium-95				<0.01							<0.01	composite				
Manganese-54				<0.01							0.01					

[a] Sensitivity of analysis, 0.3 pCi/m³; MPC, 40 pCi/m³.
[b] Sensitivity of analysis, 0.006 pCi/m³; MPC, 100 pCi/m³.
[c] ND, less than sensitivity of analysis.

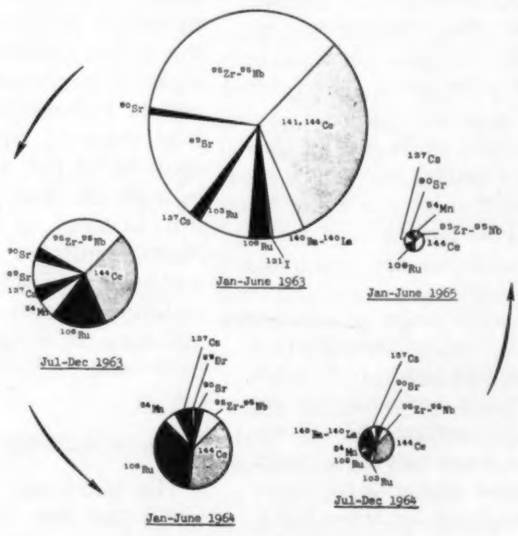

Figure 6. Relative abundance of airborne radionuclides (weapons test fallout)

Table 9. Total fallout deposited, mCi/mi²

Radionuclides	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
Alpha [a]	4.1	8.7	11.1	7.9	9.0	8.2	11.3	6.0	7.6	7.1	12.0	7.1	8.1	5.8	5.8	7.9
Strontium-90	6	8	10	10	8	8	12	9	10	7	9	11	8	9	7	9
Cesium-137	8	9	10	10	8	9	12	8	10	8	9	11	9	8	8	9
Cerium-144	9	15	26	24	19	19	36	15	19	17	31	22	16	20	12	21
Ruthenium-106	8	13	20	20	14	15	34	16	13	14	25	17	16	16	14	18
Zirconium-Niobium-95	2	2	2	3	2	2	5	2	3	3	7	2	3	2	2	3
Manganese-54	3	3	3	3	3	3	5	5	3	4	8	4	4	3	3	4

[a] Multiply by 10^{-3}.

locations along a 25-mile radius route. (These are not designated on figure 3). Samples from each quadrant of the plant and of the surrounding area were composited for weekly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.2 pCi/gram at plant perimeter and 25-mile radius locations; gamma emitters averaged 64 pCi/gram and 40 pCi/gram, respectively. Radionuclide concentrations comprising gamma activity are presented in table 10. While the exact nature of the alpha activity increase is not known, the change is commensurate with previously observed changes which appear to be seasonal. The gamma activity levels were essentially the same as during July–December 1964.

Table 10. Radioactivity on vegetation, pCi/g

	Alpha	^{137}Cs	^{144}Ce	^{106}Ru	^{95}Zr-Nb	^{54}Mn
Sensitivity of analysis	0.10	0.07	0.32	0.45	0.06	0.05
Plant perimenter (7 locations)						
Maximum	0.70	16	59	16	1	4
Average	0.23	11	42	7	1	3
25-mile radius (7 locations)						
Maximum	0.53	9	37	16	2	3
Average	0.20	6	25	6	1	2

Milk

Milk was sampled at four dairies within a 25-mile radius of the plant as shown in figure 3. Samples were taken weekly and analyzed for tritium, iodine–131, and cesium–137. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1965 are given in table 11.

The average concentrations of three radionuclides in milk (36 pCi/liter for strontium–90, <5pCi/ liter for iodine–131, and 81 pCi/liter for cesium–137) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis which allows detection of concentrations of 3,000 pCi/liter.

Table 11. Radioactivity in milk, pCi/liter

(Local dairies)

	Aiken	Allendale	North Augusta	Waynesboro, Georgia	Major distributors [a]
Tritium [b]					
Maximum	6,000	7,000	7,000	6,000	6,000
Minimum	[c] ND	ND	ND	ND	ND
Average	ND	ND	ND	ND	ND
Strontium-90 [d]					
March	31	50	24	65	30
June	17	36	36	41	35
Cesium-137 [e]					
Maximum	160	125	105	104	120
Minimum	56	51	51	57	51
Average	95	82	72	72	86

[a] Milk produced in local dairies, but sold by major distributors.
[b] Sensitivity of analysis, 3,000 pCi/liter; MPC, 300,000 pCi/liter.
[c] Less than sensitivity of analysis.
[d] Sensitivity of analysis, 1.0 pCi/liter.
[e] Sensitivity of analysis, 25 pCi/liter; MPC 2000 pCi/liter.

Algae and fish in Savannah River

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream, adjacent to, and downstream from the plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and form a part of the food chain of aquatic organisms. Data from analysis of fish and algae samples are given in table 12. Beta concentrations in algae and fish adjacent to and downstream from the plant indicate some plant contribution. Although measurably higher than similar material collected at the control station 3 miles upstream from the plant, the slight increase is of no biological significance.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 7). There is no industrial nor municipal use made of river water immediately below the plant site. During the January–June 1965 period, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the Savannah River plant site. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Table 12. Radioactivity in Savannah River aquatic specimens[a], pCi/g

Location	Algae (dry weight)				Fish (wet weight)						
	Number of Samples	Maximum	Minimum	Average	Number of Samples	Bone			Flesh		
						Maximum	Minimum	Average	Maximum	Minimum	Average
Control (3 miles upstream from Plant)	4	38	32	35	15	39	8	22	5	ND	3
Along Plant boundary	11	330	19	71	9	93	15	40	28	2	9
Highway 301 crossing (10 miles downstream from Plant)	18	100	22	46	21	60	13	28	22	2	8

ND indicates less than sensitivity of the analysis.
[a] Nonvolatile beta emitters; sensitivity of analysis—varied due to differing sample size.

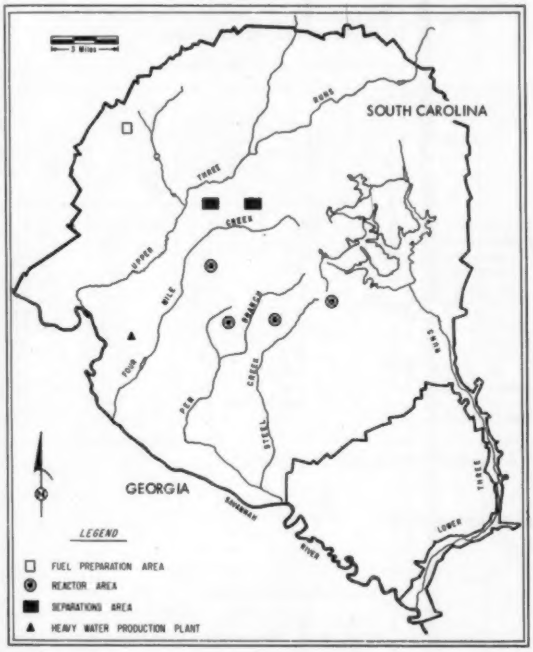

Figure 7. Savannah River Plant production areas and effluent streams

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns are collected and analyzed monthly. Concentrations of alpha activity (1.5 pCi/liter) and beta activity (7 pCi/liter) are essentially the same as those observed before plant startup in 1951. Data from analyses of all public water samples are given in table 13.

River water, analyzed weekly, was sampled continuously at four locations (upstream, adjacent to, and as far as 10 miles downstream) as shown in figure 3. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 14, average concentrations of specific radionuclides found in the river water during January–June 1965 are in table 15.

Radionuclides in river water upstream and downstream from the plant during the January–June 1965 period are shown in figure 8; the values represent the total quantities of radionuclides passing the two sampling points. Cesium–137, strontium–90, chromium–51, and tritium, released mainly from reactor areas, were the radionuclides of plant origin detectable in river water at the downstream location. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from the plant. Tritium (^{3}H), a beta emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Chromium–51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium–51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The concentration of tritium in river water averaged 3.1 percent of its MPC, and the concentration of chromium–51 was less than 0.001 percent of its MPC. Average concentrations of all radionuclides found in river water during January–June 1965 as shown in table 15, were only small fractions of the permissible concentrations.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. January–June 1965 data in table 16 are characteristic of individual station observations during the past

Table 13. Radioactivity in public water supplies, pCi/liter

	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Average
Alpha emitters [a]															
Maximum	5.4	[b] ND	ND	0.2	5.3	0.4	3.2	17	2.0	4.7	2.9	0.3	0.3	1.2	
Minimum	1.2	ND	ND	ND	1.8	ND	ND	2.6	1.1	1.3	ND	ND	ND	0.3	
Average	2.5	ND	ND	ND	3.7	0.3	0.7	7.4	1.6	2.4	0.6	ND	ND	0.7	1.5
Nonvolatile beta emitters [c]															
Maximum	9	6	9	5	17	6	13	40	10	13	18	4	12	7	
Minimum	ND	ND	5	ND	8	ND	ND	4	ND	7	5	ND	ND	ND	
Average	5	ND	6	ND	11	ND	7	23	7	9	9	ND	7	4	7

[a] Sensitivity of analysis—0.2 pCi/liter: MPC—10 pCi/liter.
[b] Less than sensitivity of analysis.
[c] Sensitivity of analysis—4.0 pCi/liter: MPC—3,000 pCi/liter.

Table 14. Radioactivity in Savannah River water, pCi/liter

	Control (3 miles upstream from Plant)	Plant Perimeter 1	Plant Perimeter 2	Highway 301 (10 miles downstream from Plant)
Alpha emitters [a]				
Jan–June 1965:				
Maximum	0.7	0.9	0.7	0.5
Minimum	[a] ND	ND	ND	ND
Average	0.3	0.2	0.2	ND
July–Dec 1964:				
Average	0.3	0.2	ND	ND
Nonvolatile beta emitters [b]				
Jan–June 1965:				
Maximum	23	34	36	24
Minimum	5	5	6	5
Average	8	13	13	10
July–Dec 1964:				
Average	10	15	14	14

ND indicates less than sensitivity of analysis.
[a] Sensitivity of analysis—0.2 pCi/liter: MPC—10 pCi/liter.
[b] Sensitivity of analysis—4.0 pCi/liter: MPC—3,000 pCi/liter.

Table 15. Average concentration of radionuclides in Savannah River water

(Concentration, pCi/liter)

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from Plant)	Highway 301 (10 miles downstream from Plant)	Percent MPC at Highway 301
Tritium(^3H)	600	1,200	9,300	3.1
Ruthenium-103, 106	3.2	ND	ND	<0.10
Cerium-141, 144	2.5	ND	ND	<0.08
Cesium-134, 137	0.6	ND	1.9	<0.10
Neptunium-239	0.9	ND	ND	<0.003
Barium-Lanthanum-140	1.6	ND	ND	<0.02
Zirconium-Niobium-95	0.5	ND	ND	<0.02
Chromium-54	4.3	ND	ND	<0.001
Strontium-89	0.3	ND	ND	—
Iodine-131	0.5	ND	ND	—
Strontium-90	0.01	1.4	2.1	—
Cobalt-60	1.4	ND	ND	<0.01
Zinc-65	1.1	ND	ND	<0.01
Manganese-54	0.4	ND	ND	<0.001

ND, Less than sensitivity of analysis.

Table 16. Environmental gamma radiation

(mR/24 hours)

	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
Maximum	0.39	0.36	0.43	0.43	0.37		0.35	0.33	0.38	0.46	0.39	0.36	0.37	0.37	0.42	
Minimum	0.34	0.26	0.36	0.31	0.32		0.30	0.23	0.29	0.28	0.32	0.32	0.32	0.30	0.27	
Average	0.36	0.33	0.39	0.36	0.34	0.36	0.33	0.29	0.32	0.36	0.34	0.34	0.34	0.33	0.33	0.33

several years; the readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variance anticipated due to differences in normal background and in instrument response characteristics.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by worldwide fallout from nuclear weapons testing during past years. Fallout from the Chinese nuclear test on May 14, 1965, was detected at SRP on air filters. Beta activity in air, which shows no relationship to plant operations, was about one-fifth of that for the same period of 1964. Radioactive materials in fresh fish continued to be far below levels considered significant from a health standpoint. The average concentration of radionuclides in river water did not exceed 3.1 percent of the maximum permissible concentrations.

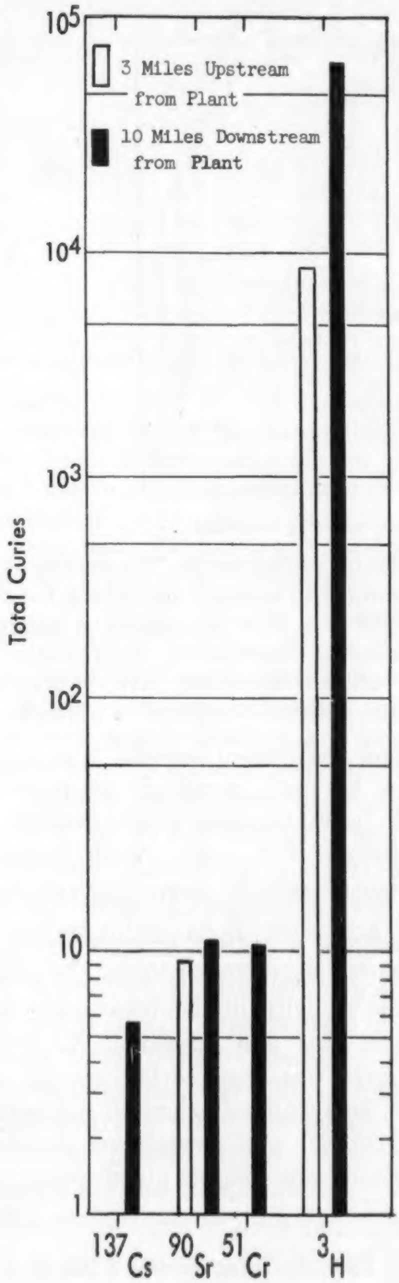

Figure 8. Radionuclides in river water during January-June 1965 (only strontium-90 and tritium were detectable upstream)

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1961	*September 1962*
Calendar Year 1962	*August 1963*
Calendar Year 1963	*August 1964*
January-June 1964	*February 1965*
July-December 1964	*August 1965*

4. Shippingport Atomic Power Station[9] January-June 1965

Duquesne Light Company
Shippingport, Pennsylvania

The Shippingport Atomic Power Station is operated for the Atomic Energy Commission by the Duquesne Light Company. The plant site is located near Shippingport Pennsylvania, along the Ohio River about 25 miles northwest of Pittsburgh.

The pressurized water reactor with core 1 ("seed and blanket" design) achieved full power on December 23, 1957, and has operated continuously except for shutdowns which were necessary for maintenance and "seed" refueling. In February 1964, the reactor was shutdown for the replacement of core 1 with core 2, the decontamination of the primary system, and the commencement of other associated reactor plant modifications. The reactor remained shut down until April 1965, at which time operations were recommenced.

An environmental monitoring program was begun 2 years before plant startup to determine the background levels of radioactivity in the environment. This program was then continued after plant startup to ensure that radioactive waste discharges from normal plant operations do not cause significant changes in these levels in the plant environment. The present program of environmental monitoring consists of measurements of radioactivity in air, fallout, and Ohio river water. Figure 9 shows the sampling locations.

Liquid radioactive waste disposal

The concentration limits for the discharge of radioactive wastes at Shippingport are based on a knowledge of the radionuclide mixture making up the waste and on the radiation protection standards of Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524; and Chapter 4, Article 433 of the Rules and Regulations, Commonwealth of Pennsylvania Department of Health. The discharge of tritium, a radioactive isotope less hazardous than fission and activation corrosion products, is controlled separately based on its own limit.

[9] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the First Half of 1965" PNRO-DEV-135.

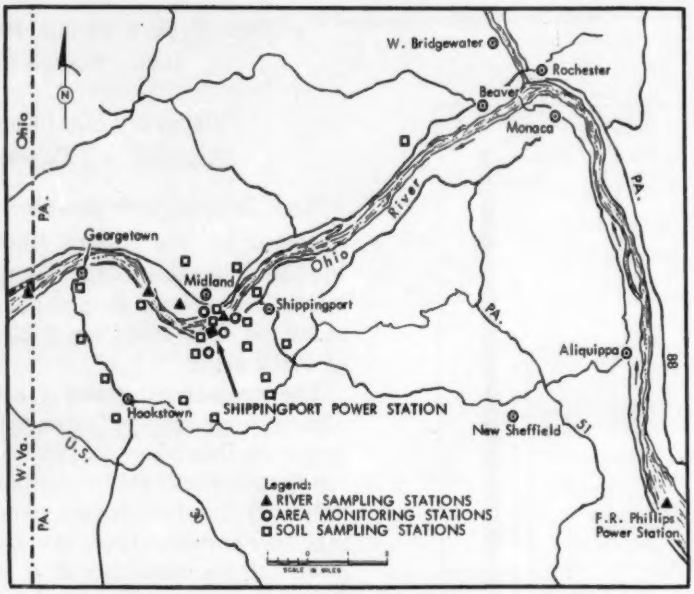

Figure 9. Shippingport Power Station sampling locations

The liquid effluent from the plant radioactive waste disposal system is carefully monitored before, during, and after release to the Ohio River to ensure that the concentration limits recommended by the above regulations are not exceeded.

The liquid radioactive wastes discharged during the first half of 1965 are summarized below. The monthly average concentrations of gross radioactivity shown in table 17 include normal background radioactivity and are calculated after total radioactive waste discharges are diluted in the condenser cooling water effluent channel. The maximum total discharge in a single day during the first half of 1965 was 1.78 millicuries.

the hold-up tanks prior to discharge, and the monthly average concentration of the waste in the effluent channel after dilution with the

Table 17. Total radioactive waste, exclusive of tritium, discharged into the Ohio River, January–June 1965

Period	Total discharges (millicuries)	Average discharge per day (millicuries)	Average concentration effluent channel (pCi/liter)
January	8.56	0.276	4.03
February	10.4	0.372	3.90
March	23.5	1.090	5.25
April	15.3	1.640	4.85
May	8.87	0.286	2.56
June	7.74	0.258	2.28
Total 6 months	74.4	0.652	3.86

Table 18 is a summary of the tritium that was discharged into the Ohio River, the monthly average concentration of tritium in

condenser cooling water. The maximum tritium discharged in a single day during the first half of 1965 was 20 mCi. Automatic samplers are installed at the station's river water influent and effluent to collect river water samples continuously for comparative purposes.

Since the effluent sampler was inoperative during the first 3 months of this report period, daily "grab" samples were collected. Weekly composites of the daily "grab" samples and continuous samples were analyzed for gross beta and gross alpha radioactivities in the suspended and dissolved solids. The potassium-40 radioactivity in the total solids of these samples was also measured. No significant difference was observed between the average alpha, beta, and potassium-40 radioactivity in the upstream and downstream samples. The results of these analyses are shown in table 19.

Table 18. Tritium released to Ohio River January–June 1965

Period	Total discharges (millicurie)	Average discharge per day (millicurie/day)	Average concentration in hold-up tank (pCi/liter) [a]	Average concentration in effluent channel (pCi/liter)
January	[b] —	—	<500,000	—
February	—	—	<500,000	—
March	—	—	<500,000	—
April	—	—	<500,000	—
May	—	—	<500,000	—
June	81	2.7	688,000	67.6
Total 6 months	81	0.447	520,000	10.9

[a] Minimum detectable tritium concentration = 500,000 pCi/liter.
[b] Dash indicates no tritium detected.

Table 19. Average concentration of radioactivity in the Ohio River, January–June 1965

Type of radioactive material	Concentration, pCi/liter					
	Upstream samples			Downstream samples		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha						
Suspended solids	5.35	0.11	0.94	4.82	<0.03	0.90
Dissolved solids	3.41	0.01	0.84	1.86	<0.03	0.66
Total solids	8.76	0.12	1.78	6.68	<0.06	1.56
Beta						
Suspended solids	33.9	2.19	9.98	46.6	1.21	9.66
Dissolved solids	16.4	1.76	8.75	91.0	4.20	9.36
Total solids	50.3	3.95	18.77	137.6	5.41	19.02
Potassium-40						
Total solids	7.20	2.50	8.40	8.40	2.50	4.10

Atmospheric release of radioactive materials

During the first half of 1965, no radioactive gas or airborne particulate radioactivity was released from Shippingport. Station operations did not require the controlled release of any radioactive gas and the incinerator, which is normally used for burning contaminated, combustible waste, was inoperative.

Environmental monitoring

Three area monitoring stations were used to collect fallout, to detect and record levels of external beta-gamma radiation, and to detect and record levels of airborne particulate radioactivity in the power station vicinity. Stations 1, 2, and 3 are located 150 yards southeast, 150 yards west, and one-half mile north-northwest of the reactor building, respectively.

All three stations include a continuously moving paper tape air sampler with an end-window Geiger-Mueller detector and a recorder. Since the radioactivity is measured by the detector only one-half hour after its collection, naturally occurring radon and thoron daughters are also included. The data collected by the stations are checked and averaged weekly. The 6-month averages of these data from stations 1, 2, and 3 are listed in table 20.

Table 20. Average concentration of airborne particulate radioactivity, January–June 1965

Station		Concentration, pCi/m³		
Number	Percent of time not working	Maximum	Minimum	Average
1	7.7	7.85	0	1.40
2	19.2	18.2	.0785	2.52
3	23.1	7.85	0	1.10

External beta-gamma radiation levels at each station are continuously measured and recorded by a Geiger-Mueller detector and a recorder. The data collected at each station are checked and averaged weekly. The results of these measurements, as shown in table 21, indicate that the radiation levels for stations 1 and 3 were not significantly different from the averages for these stations for previous years. The average radiation level for station 2 was higher than normal due to the handling and storage of radioactive materials in the laydown building area, which is near station 2.

Table 21. Beta-gamma background radiation levels January–June 1965

Station number	Radiation levels (mr/hr)		
	Maximum	Minimum	Average
1	0.48	0.008	0.016
2	0.60	0.020	0.140
3	0.052	0.008	0.022

The radioactive fallout at each station was collected in pots over a one-month period and analyzed for beta radioactivity. As shown in table 22, and 6-month averages for the stations did not differ significantly to indicate that any radioactivity was released by the power station.

Table 22. Beta radioactivity in fallout

Station number	Deposition rate, nCi/m²/month		
	Maximum	Minimum	Average
1	78.0	10.7	23.9
2	48.6	11.4	20.8
3	43.6	10.6	19.9

Average for all stations: 21.6 nCi/m²/month
Maximum: 78.0 nCi/m²/month
Minimum: 10.6 nCi/m²/month

Summary

During the first half of 1965, measurements of radioactivity were made in the Ohio River and the atmosphere in the vicinity of the Shippingport Atomic Power Station. The results of these measurements indicate that the radioactive material released by the power station into the Ohio River did not result in a significant change in the naturally occurring radioactivity in the environment.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	*April 1962*
July 1962–June 1963	*March 1964*
July–December 1963	*November 1964*
Calendar Year 1964	*August 1965*

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, JANUARY 1966

During January 1966, three United States nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Low yield tests (less than 20 kilotons of TNT equivalent) were conducted underground on January 13 and 21 and a low-intermediate yield test (20 to 200 kilotons of TNT equivalent) was conducted underground on January 18, 1966.

IN MEMORIAM

Duncan C. Clark

With deep sadness we report the death on January 13, 1966, of Mr. Duncan C. Clark, who for the past six years has been Director, Division of Public Information of the United States Atomic Energy Commission. Mr. Clark served as a member of the Board of Editorial Advisors of Radiological Health Data since its inception, representing the AEC.

Mr. Clark entered Federal service in 1947 as administrative assistant to Congressman John A. Carroll of Colorado. In 1951 he joined the staff of the House Committee on Small Business as an analyst, transferring to the AEC in 1952 as a public information officer. Four years later he was named Deputy Assistant Director for Public Information, and in 1957 he was appointed Assistant Director for Public Information, a position he held until 1960, when he became Director.

During Mr. Clark's service with the AEC he drew upon his extensive background and training to clarify for reporters of many nations the many facets of the atomic energy program, including radiological safety in weapons testing, fallout, biology and medicine, radioisotopes, research, raw materials, and reactor safety.

On February 28, 1958, Mr. Clark received the AEC's Sustained Superior Performance Award, which read in part:

"The vital task of keeping the public correctly and adequately informed regarding the health and safety aspects of the Commission's operations has largely been a planning and performance responsibility of Duncan Clark, Deputy Assistant Director for Public Information in the Division of Information Services. Primarily for this work, but also for other valuable services to the Commission, Mr. Clark is recommended for an award."

His colleagues and associates, who experienced his warmth, his gentleness, his understanding, and his strength of spirit, feel a keen sense of loss in his untimely passing.

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